MINERAL REPORT 36

CANADIAN MINERALS YEARBOOK 1987

REVIEW AND OUTLOOK

Energy, Mines and Resources Canada
Énergie, Mines et Ressources Canada

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Minister of State
(Forestry and Mines)

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Foreword

The past year was an exciting one for the Canadian minerals industry. The overall value of its production in 1987 reached $36 billion, an increase of 11% over 1986. Moreover total metallic minerals increased in value by more than 24% from $8.8 billion in 1986 to $10.9 billion in 1987. In May 1987, Minister Merrithew released the Mineral and Metal Policy of the Government of Canada. The document showed that the Government is committed to continuing to provide a positive environment for the Canadian minerals industry to explore for, mine, process and market mineral and metal resources. Another tangible example of the Government's commitment and support for Canadian industry including minerals was the Free Trade Agreement with the United States. With this important commercial agreement the Government has taken a major step to ensure that industry has unimpeded access to the world's largest economy. The mineral industry which has been supporting the Government's efforts will certainly benefit substantially from this historic and forward looking initiative.

This 101st edition of the Canadian Minerals Yearbook reports on the activity of the mineral industry during 1987. The General Review identifies the predominant economic events of 1987 and indicates the major trends in the Canadian economy. It also covers the general developments and overall patterns of the mineral industry during the year. The regional and international scenes are covered in separate reviews while new chapters on Labour and Employment and Canadian Mineral Exploration have been added. The 47 commodity chapters - the work of the Mineral and Metal Commodities Branch of the Mineral Policy Sector - feature economic developments, uses, prices, exports and production and consumption figures specific to each commodity. The Outlook section under each commodity review provides a forecast of the industry's future position.

The basic statistics on Canadian production, trade and consumption, unless otherwise stated, were collected by the Information Systems Division, Mineral Policy Sector of Energy, Mines and Resources Canada, and by Statistics Canada. Market quotations were taken mainly from standard marketing reports. Corporate data were obtained directly from company officials through surveys or correspondence, or were extracted from annual reports. The Tariffs (chapter 73) are reproduced from the Canada, Notice of Ways and Means Motion, Customs Tariff tabled on October 2, 1987 and the proposed United States Tariff Schedule Annotated in the Harmonized System Nomenclature, Office of the USTR, July 1987. Energy, Mines and Resources Canada is grateful to all those who contributed information used in the preparation of this report.

Additional copies of the Yearbook can be purchased from the Canadian Government Publishing Centre. Reprints of individual chapters and Map 900A, Principal Mineral Areas of Canada, may be obtained free of charge from:

Publications Distribution Office
Mineral Policy Sector
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Previous editions of the Canadian Minerals Yearbook have been deposited in various libraries across Canada.

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General Review

D. PILSWORTH

THE CANADIAN ECONOMY IN 1987

The Canadian economy grew at an exceptional rate during the first ten months of 1987. Real economic growth, measured by Gross Domestic Product (GDP), surged at an annual rate of 6.1% in both the first and second quarters of 1987, a big improvement over the fourth quarter of 1986 when growth had slowed to 0.2%. Unemployment at 8.6%, was the lowest level recorded since January 1982, and the projected federal deficit of $32 billion was below the $38.3 billion recorded in 1985. Consumer spending had remained buoyant, fuelling an economic recovery that was well into its fifth year and the expected increase in business investment appeared to have arrived.

Canadian business in a lower debt position, took advantage of the strong performance by the economy and increased its planned 1987 capital expenditures by $6.6 billion. This increase brought the total for the year to $106 billion, an 11% improvement over the $95.7 billion estimated for 1986. The increase in overall investment was influenced by a rise in commodity prices, the opening up of Canada's financial markets to competition, continuing consumer spending and an improvement in corporate profits that rose by 28% in both the first and second quarters of 1987.

On the other hand, Canada's trade picture was less positive than anticipated. In the second quarter of 1987, the current account deficit of $2 billion remained high by historical standards, continuing the trend evident since the first quarter of 1986. (The current account records the flow of goods, services, investment income and transfers between Canada and the rest of the world). The merchandise trade surplus, historically a major stimulus to economic growth in Canada, had dropped from $3 billion in the first quarter of 1987 to $2.5 billion in the third quarter as a result of the declining value of export trade.

Signs of trouble on the inflation front began to surface in June, when the Consumer Price Index reached an annual rate of 4.8%, the highest level in more than three years. Interest rates, initially lower than those of 1986, had started to edge up again, leading to fears of a new inflationary spiral, and consumer spending showed signs of waning as third quarter GDP came in at a lower annualized rate of 4.4%.

Canada's major trading partner, the United States, faced a difficult year in 1987 with economic problems stemming from a weakening dollar, and an apparently intractable deficit at home and abroad. A lack of confidence in the falling United States dollar combined with rising interest rates and international trade imbalances precipitated a massive sell-off of North American equity holdings that quickly spread world-wide. On October 19, the international financial markets fell in a manner reminiscent of the crash of 1929 and the optimistic forecasts for the Canadian economy for 1988 were suddenly thrown into doubt.

In the immediate aftermath of the stock market plunge, the United States dollar fell to its lowest level since World War II, relative to the German mark and the Japanese yen.

The Canadian dollar, after reaching a high for the year of US77¢ on October 19, fell to US75¢. This loss of value of the Canadian dollar was positive in that Canadian exporters gained an edge in selling to the United States markets where goods from countries with costly currencies were becoming increasingly expensive.

The excessively large trade imbalances between the United States and its trading partners fostered an attitude of increasing protectionism in the United States. It was against such a backdrop that Canada and the United States concluded negotiations for a bilateral trade agreement to be implemented over the next decade.

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THE MINERAL INDUSTRY IN 1987

Rising prices and sustained productivity increases resulted in a much improved performance for Canada's mineral industry in 1987 compared to 1986. The price increases reflected tighter global supply of minerals as the mine closures and smelter rationalizations of the past five years finally brought production more in line with demand.

In addition, the combined downward slide of the United States and Canadian dollars was beneficial to Canadian resource-based companies, whose products in world markets became more competitively priced as a result. By year end, however, the Canadian dollar was showing renewed strength which may be sustained in 1988.

Operating profits in the metal-mining industry rose to $64 million in the second quarter of 1987, up markedly from a loss of $45 million in the first quarter. This performance was especially noteworthy because in only five of the past twenty quarters has a profit been recorded. The improved profitability was largely attributable to higher metal prices. Mining companies had responded to the severe price downturns for their products in the early 1980s by cutting back their work forces, by implementing more efficient mining methods, by adopting new technologies and by closing high cost operations.

Investment expenditure intentions for nonfuel mining in 1987 reflected this increased strength and optimism. The intended expenditure of $2.0 billion for investment in new capital in 1987 was an increase of nearly 14% over the $1.8 billion estimated for 1986.

The value and volume of Canadian mineral production increased in 1987 compared with 1986. The value of output for the Canadian mineral industry, including metallic minerals, nonmetallic minerals, structural materials and fuels, totalled $36.0 billion in 1987 compared with $32.0 billion in 1986.

The metallic minerals sector was the star performer in 1987, with value of output reaching nearly $11.0 billion, an increase of 24% over the $8.8 billion recorded in 1986. On the other hand, the value of output of the nonmetallics remained at $2.5 billion with little change from the previous year. The value of output for structural materials increased by 13% from $2.3 billion in 1986 to $2.6 billion in 1987. The fuel sector, which includes crude petroleum, natural gas, natural gas by-products and coal accounted for nearly $20.0 billion of the overall value of mineral output, a 6.4% increase over the previous year.

The top ten commodities in terms of value of output in 1987 were as follows: petroleum, $12.0 billion; natural gas, $4.3 billion; gold, $2.2 billion; natural gas by-products, $2.0 billion; copper, $1.8 billion; zinc, $1.7 billion; coal, $1.6 billion; nickel, $1.3 billion; iron ore, $1.3 billion; and uranium, $1.1 billion.

Alberta's contribution to mineral output represented the largest share, reaching $17.1 billion or 48% of total output, up from $16.3 billion in 1986. Ontario was second with a value of $5.7 billion or 16% of the total, up from $4.8 billion in 1986. In third through sixth places respectively were British Columbia at $3.4 billion, Saskatchewan at $3.0 billion, Quebec at $2.5 billion and Manitoba at $1.0 billion. For all the remaining provinces with the exception of Newfoundland, value of output increased over the previous year.

Employment levels throughout the industry remained relatively unchanged in 1987, suggesting that cut-backs associated with industry rationalization had stabilized. Employment in mining (coal included) and mineral manufacturing was estimated in 1987 to be 383 000, virtually unchanged from 1986.

Employment in metal mines, nonmetal mines including coal, and structural materials, forecasted to be 76 000 in 1987, appeared to be levelling off after several years of decreases. Employment in smelting and refining, and the crude steel industries was down slightly to 73 000 while mineral manufacturing employment, estimated at 232 000, remained essentially unchanged from the previous year.

Flow-through share financing approached one billion dollars during 1987. The success of the program was largely a result of the continuing exploration expenditures associated with the search for gold.

Exports of Canadian minerals in 1987 continued to make an important contribution to Canada's merchandise trade surplus. In the first nine months of 1987, exports of crude and fabricated minerals (excluding fuels), reached $12.0 billion. Crude minerals accounted for $4.0 billion, while fabricated minerals made up the remaining $8.0 billion. Exports to the United States accounted for about 60% of the total in 1987, followed by the European Economic Community (excluding the United Kingdom) at 9.5%, Japan at 7.5%, and the United Kingdom at 4.7%. Mineral exports, including fuels, made up nearly one quarter of the value of Canada's domestic exports over the first nine months of 1987.

Imports of crude and fabricated minerals totalled nearly $6.0 billion over the first nine months of 1987, down slightly from the $6.5 billion recorded over the same period in 1986.

COMMODITY TRENDS

The value of gold output in Canada increased to a new high of $2.2 billion in 1987, up $500 million from 1986. The quantity of gold produced increased from 103 t in 1986 to 118 t in 1987. The continuing success of flow-through share funding in raising capital for exploration, combined with an average gold price of US$447/oz. in 1987, maintained much of the focus on this commodity. Of particular interest was the merging of Placer Development Limited, Dome Mines, Limited and Campbell Red Lake Mines Limited to form Placer Dome Inc. to become the largest gold producer in North America.

Silver staged a comeback in 1987, with the average price at close to US$7.00/oz. in 1987 compared to an average price of US$5.46 in 1986. The value of output in 1987 was $374 million, up from $275 million in 1986. Production also rose from 1 088 t in 1986 to 1 250 t in 1987.

The price of copper surged on the LME to a seven-year high of US$1.45/lb. in 1987. A lower valued United States dollar, tight inventories and stronger than expected demand contributed to shortages that led to higher prices. In 1987, the quantity and value of copper output increased by nearly 10% and 30% respectively.

The volume of lead output increased to 390 503 t in 1987 from 334 342 t in 1986 and the value increased to $412.8 million from $227.7 million in 1986. The price of lead on the LME had averaged about US18¢/lb. in 1986 and by May of 1987 had risen to more than US31¢/lb. These higher prices were partially attributable to increases in demand combined with supply disruptions. It appears likely that supply and demand will remain closely balanced in 1988.

Volume of zinc output was up to 1.3 Mt in 1987, a 35% increase over the nearly 1.0 Mt reported in 1986. The value of output also increased in 1987 to nearly $1.7 billion, up from $1.2 billion in 1986. A steady decline in zinc metal stocks over the past five years has brought down inventories to a level which should help sustain higher prices.

The volume of nickel output in Canada increased by nearly 15% to 187 805 t in 1987 while value increased by 32% to nearly $1.3 billion. The price of nickel on the LME reached a five-year high of US$4.23/lb. on December 30, 1987, up from US$1.60/lb. at the beginning of the year. INCO Limited, the world's largest producer of nickel, reported third quarter earnings of $41.4 million, compared with earnings of $3 million in the corresponding period in 1986.

Molybdenum producers continued to face an oversupply situation in 1987. At the start of the year, Metals Week dealer price for molybdenum was US$3.05/lb., but by year end the price had declined to US$2.80. In spite of somewhat negative market conditions, Canada's output of molybdenum in 1987 increased from 11 251 t in 1986 to 11 581 t and the value increased from $90.1 million to $92.6 million over the same period.

In 1987, Canada's iron ore industry continued to face the harsh realities of an oversupply in international markets. This, in combination with a stagnant demand for steel did little to help prices. Japan, the biggest iron ore buyer in the world, reduced its imports of iron ore from traditional suppliers such as Canada and the United States in 1987, although improvements in Korean and Taiwanese markets may help to offset the Japanese cutbacks. Production of iron ore in Canada remained relatively stable in 1987 with volume of output up by 4% to 37.6 Mt and value of output down by 7% to $1.3 billion.

Asbestos mine production in Canada is expected to remain at the current level for the remainder of this decade. The decline in production has however stabilized. Canadian volume and value of output at 665 000 t and $235 million respectively, were relatively unchanged in 1987 from the levels reported in 1986.

In August of 1987, the Canadian potash industry became involved in a dispute with the United States over the price at which Canadian potash was being sold in that country. In the absence of a satisfactory resolution to the problem, the United States was prepared to subject Canadian potash to an import duty. However, by year end a satisfactory agreement between the two countries had been reached. Under the new arrangement, Canadian potash producers have agreed not to sell potash in the United States at prices which Washington trade authorities deem 'unfair'. Volume of output in 1987 was 7.5 Mt while value of output was $705.8 million.

OUTLOOK

Economists generally agree that the Canadian economy is likely to grow at a slower though still healthy pace in 1988. An annual rate of real growth of about 2.6% is forecast compared to the 3.7% to 4.0% experienced in 1987. Since Canada is now into the sixth year of its current economic expansion, such growth would be considered quite acceptable. The inflation rate is expected to remain relatively stable, rising very slightly from 4.5% in 1987 to about 4.8% in 1988, and the unemployment rate will probably hold steady at 8.7%, down from the 9% average of 1987. Interest rates are also likely to remain level in 1988, unless inflationary pressures build later in the year.

Growth in consumer spending, on the other hand is likely to moderate in 1988 to 3%, down from the 4.4% recorded in 1987 and housing starts are also expected to decline. This level of spending is considered reasonable and will contribute to sustained growth in the economy.

As the Canadian economy enters its sixth year of expansion since the 1981-82 recession, business non-residential investment is finally contributing to stronger growth. Business spending is likely to be a major area of strength in both the United States and Canada in 1988. In Canada, strong gains in spending on machinery and equipment, particularly in the resource industries, should result in an average increase of 6.6% in real business investment in 1988, a noticeable improvement over the 6.2% increase in 1987 and the 2.2% increase of 1986.

Slower growth is expected in the United States in 1988, where real growth in GNP may drop to 2.2%, down slightly from the 2.7% recorded in 1987. This could reduce growth in Canadian exports, particularly for automobiles and lumber. However, if the economy of the United States bounces back in the second half of 1988, as some analysts predict, the negative impact on Canadian exports could be short-lived. The Canadian export sector will remain strong in 1988, and export growth is expected to outpace the rise in imports and improve Canada's current account balance.

Mining and other resource-based industries are expected to be a source of strength for the Canadian economy in 1988. After the difficult recession years, the Canadian mineral industry seems poised for a healthy year. The challenges of rationalization and restructuring have been met; increases in labour productivity have been sustained; production costs have been brought down to more competitive levels; and prices for several key metals have moved upwards. In the words of a prominent industrialist, the industry has become, "Trim, tough and competitive". Five years of oversupply and low prices appear to have ended. Fuelled by unusually tight inventories and sustained economic growth in western and Far East economies, mineral markets appear to be balanced and tight.

A bilateral free trade agreement with the United States, scheduled to come into place in 1989, should enhance export opportunities for Canada's metals and minerals. Canada's mineral industry, already a strong international competitor, has been built on the principles of free trade. New market access for minerals and metals should generate economies of scale which could make this important sector more competitive not only in North America, but also at a world level.

There are however, challenges still to be met. For example: international competition for the mineral industry remains fierce; declining intensity-of-use for some metals threatens long term demand; and instability in world financial and currency markets adds risk to the economic environment.

Overall, however, the future for the Canadian mineral industry looks bright for 1988. The encouraging gains of the past few years will enable the industry to maintain its new bullishness and remain an important contributor to the economy of Canada.

CANADA, PRODUCTION OF LEADING MINERALS, 1986 AND 1987

	1986	1987	Percent change 1987/1986	1986	1987	Percent change 1987/1986
	(000 tonnes except where noted)			($ millions)		
Metals						
Gold (kg)	102 899.0	117 834.0	14.5	1 689.3	2 242.9	32.8
Copper	698.5	767.3	9.8	1 426.4	1 844.6	29.3
Zinc	988.2	1 329.4	34.5	1 200.6	1 693.7	41.1
Nickel	163.6	187.8	14.8	979.1	1 288.5	31.6
Iron ore	36 167.0	37 553.0	3.8	1 342.7	1 254.2	-6.6
Uranium(U)(t)	11 502.0	13 202.0	14.8	1 042.3	1 121.1	7.6
Lead	334.3	390.5	16.8	227.7	412.8	81.3
Silver (t)	1 088.0	1 250.0	14.9	275.0	373.7	35.9
Molybdenum (t)	11 251.0	11 581.0	2.9	90.1	92.6	2.8
Nonmetals						
Potash (K_2O)	6 752.0	7 465.0	10.6	584.3	705.8	20.8
Sulphur, elemental	6 966.0	6 888.0	-1.1	857.6	650.8	-24.1
Salt	10 332.0	10 294.0	-0.4	239.5	235.4	-1.7
Asbestos	662.0	665.0	0.5	234.1	235.2	0.5
Gypsum	8 803.0	8 811.0	0.1	83.1	87.9	5.8
Structurals						
Cement	10 611.0	12 205.0	15.0	824.3	976.0	18.4
Sand and gravel	257 971.0	260 265.0	0.9	678.6	729.1	7.4
Clay products	..	..	..	179.5	210.2	17.1
Lime	2 243.0	2 271.0	1.2	171.4	177.9	3.8
Fuels						
Petroleum (000 m^3)	85 468.0	87 108.0	1.9	9 611.8	11 992.7	24.8
Natural gas (million m^3)	71 896.0	71 962.0	0.1	5 623.1	4 310.7	-23.3
Natural gas by-products (000 m^3)	19 127.0	20 879.0	9.2	1 802.5	2 016.9	11.9
Coal	57 811.0	59 790.0	3.4	1 725.9	1 635.0	-5.3

.. Not applicable.
Note: Figures have been rounded.

CANADIAN, EXPORTS OF MINERALS, BY STAGE OF PROCESSING[1]

	Year			1st 9 months		% change 1st 9 months 1987 / 1st 9 months 1986
	1976	1981	1986	1986	1987	
			($ millions)			
Crude						
Ferrous	920.5	1 465.3	1 107.8	778.7	696.1	-10.6
Nonferrous	743.3	1 393.1	1 081.4	748.4	868.9	16.1
Industrial	1 131.1	2 682.2	2 840.0	2 188.3	1 959.2	-10.5
Fuels	4 531.4	8 201.3	8 274.7	6 360.2	6 761.3	6.3
Total	7 326.3	13 741.9	13 303.9	10 075.6	10 285.5	2.1
Scrap						
Ferrous	63.9	75.3	107.2	70.1	92.4	31.8
Nonferrous	105.5	313.9	434.1	312.3	370.9	18.8
Total	169.4	389.2	541.3	382.4	463.3	21.2
Smelted and refined						
Ferrous	115.6	475.1	278.0	199.0	155.3	-22.0
Nonferrous	2 654.2	5 836.5	7 613.3	5 302.0	4 481.1	-15.5
Fuels	728.7	2 800.2	2 589.1	1 908.5	1 865.0	-2.3
Total	3 498.5	9 111.8	10 480.4	7 409.5	6 501.4	-12.3
Semi-manufactured						
Ferrous	742.1	1 874.8	2 164.9	1 552.7	1 854.5	19.4
Nonferrous	269.6	586.9	865.3	634.9	802.3	26.4
Industrial	327.2	711.1	978.7	750.6	763.0	1.7
Fuels	19.0	512.9	182.9	154.0	144.1	-6.4
Total	1 357.9	3 685.7	4 191.8	3 092.2	3 564.0	15.3
Total mineral exports (including scrap)	12 352.1	26 928.6	28 517.4	20 959.7	20 814.2	-0.7
Total domestic exports, all products	37 328.5	81 203.3	116 587.7	86 088.0	88 198.8	2.5
Crude minerals as % of exports, all products	19.6	16.9	11.4	11.7	11.7	
Total minerals as % of exports, all products	33.1	33.2	24.5	24.3	23.6	

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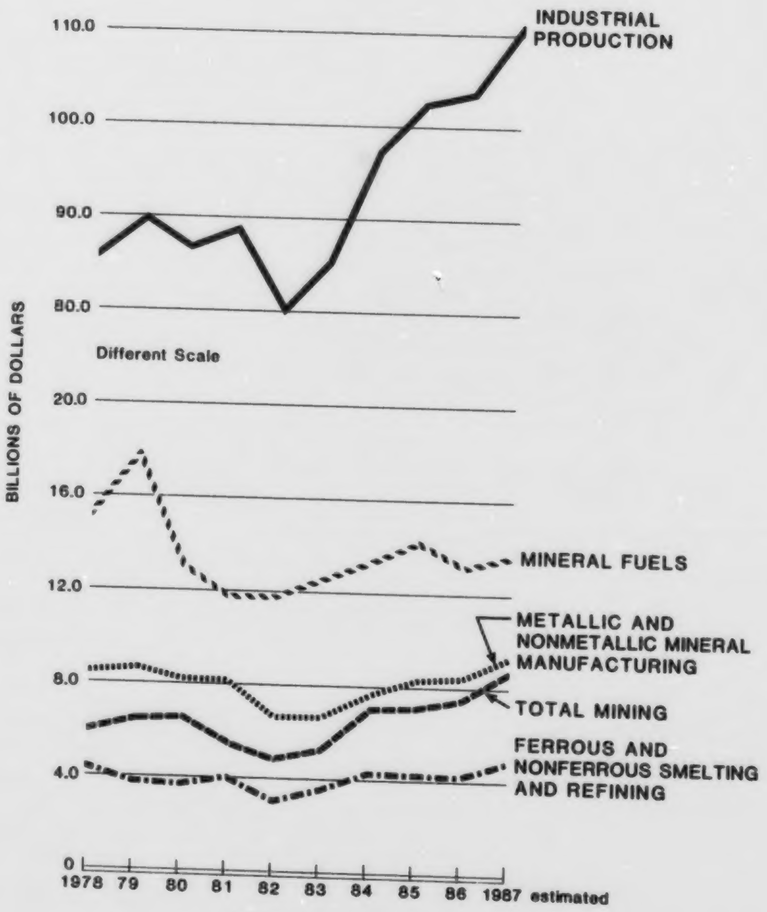
[1] The trade data was compiled on the basis of a mineral industry definition developed by the Mineral Policy Sector of EMR in 1977.

FIGURE 1

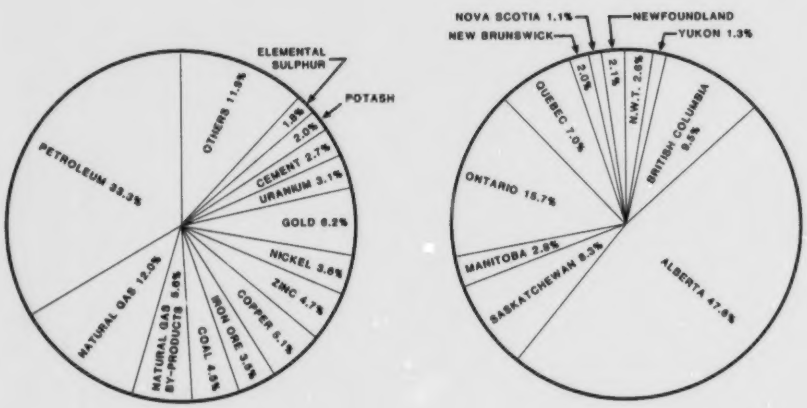
GROSS DOMESTIC PRODUCT IN 1981 DOLLARS



SOURCE: STATISTICS CANADA

FIGURE 2

CANADA, MINERAL PRODUCTION, 1987



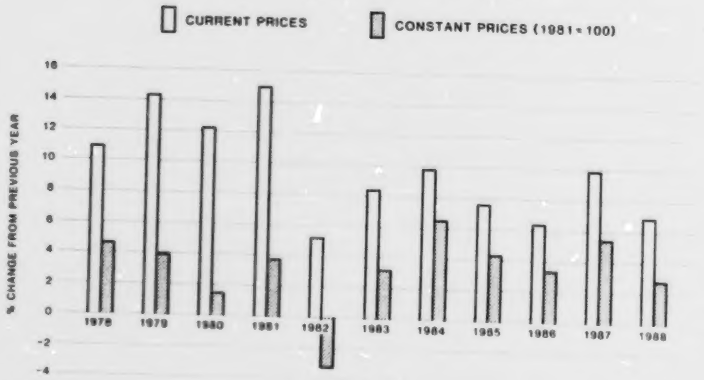
% OF TOTAL BY COMMODITY

% OF TOTAL BY PROVINCE

FIGURE 3

TRENDS IN CANADIAN ECONOMIC ACTIVITY

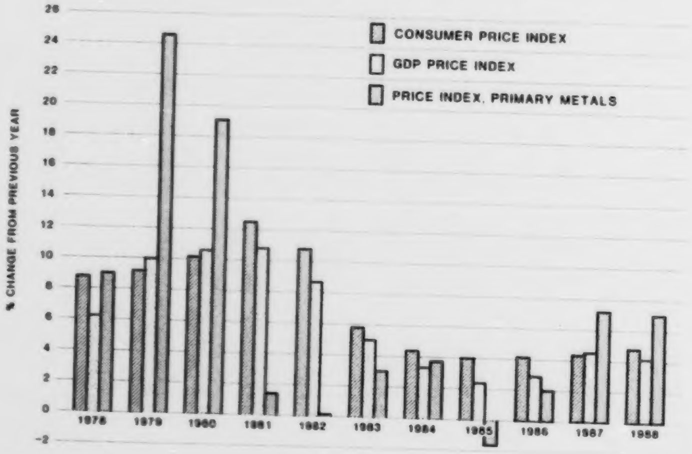
(% CHANGE IN GROSS DOMESTIC PRODUCT)



NOTE FIGURES FOR 1987 AND 1988 ARE ESTIMATED

FIGURE 4

GENERAL CANADIAN PRICE TRENDS



NOTE. FIGURES FOR 1987 AND 1988 ARE ESTIMATED

International Review

CANADA'S MINERAL INDUSTRY IN A CHANGING INTERNATIONAL ECONOMY

W.G. CHAMBERS

Although the export performance of the industry has been relatively good in that exports continued to grow throughout 1987, the commercial fortunes of the industry remain, in large measure, highly sensitive, at times vulnerable, to an array of political and economic forces which can and do effect significant changes in international mineral markets.

The capacity to export and retain an optimum share of the world market for minerals and mineral materials is vital for the continued commercial viability of the industry. But the realization of this objective is, in the face of major destabilizing market distortions, akin to a sisyphean task.

Two basic conditions are necessary to gain market access and maintain an optimum market share. First, the industry must be highly cost-competitive. Second, barriers to market access should be at a minimum. These conditions may not hold in cases where a country has a monopoly in the production and distribution of one or more mineral commodities. However, that situation does not obtain in Canada.

Canadian mineral producers are price takers not price setters in international mineral markets. Thus cost-competitiveness and aggressive marketing are indispensable for effectively competing in both foreign and domestic mineral commodity markets. Experience has shown, however, that the combined impact of a comparative cost advantage and up-to-date marketing practices may not in themselves be sufficient to ensure market access or the retention of market share. For Canadian mineral producers, this phenomenon gives cause for much concern. It causes some to question the effectiveness of prices and movements in relative prices as determinants of commodity trade flows, thereby casting doubt on the validity of the universally accepted doctrine of comparative cost advantage.

In light of this, it is vitally important to examine closely the market for minerals and metals so as to ascertain what mechanisms, other than prices, determine the pattern and direction of mineral commodity trade flows. That kind of information is essential for understanding and assessing the extent to which factors other than prices affect Canada's mineral trade, as well as for evaluating the efficacy of measures that are being undertaken by some international institutions and agencies to promote freer trade.

MARKET REALITIES

The operation of the international market place for minerals and metals is far more complex than is usually presumed. Although prices and relative price movements are the major determinant of trade flows, there are also other mechanisms which significantly influence the pattern and direction of internationally traded goods and services. These latter mechanisms, which may be employed either to facilitate or to constrain the operation of the price mechanism, fall into three broad categories. These categories are:

- unilateral trade policies, such as sourcing strategies of resource deficient industrialized economies, exchange rate and other macroeconomic policies, export financing practices, tariff and non-tariff measures, etc.
- bilateral trade arrangements or various forms of trade reciprocity.
- international institutional arrangements which fall within the purview of such institutions as the GATT, the International Monetary Fund (IMF), the World Bank, United Nations Conference on Trade and Development (UNCTAD), etc.

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The increased importance of international trade within all sectors of the economy; the internationalization of entrepreneurship, technology, marketing and consultative services; and capital markets have enmeshed national economies into a global network of interdependent economic relations. In consequence, market economies have become more open (in the sense of having higher ratios of trade to total output) and more sensitive to developments in the economies of other nations.

This global integration of national economies has been a mixed blessing. It has brought substantial economic benefits to trading nations. But in order to secure these benefits, nation states have had to sacrifice some of their sovereignty.

For the global economy to realize sustained economic growth and relative price level stability, the economic policies of trading nations should, at all times, be consistent with that global objective. Most countries find this requirement of interdependence difficult to comply with, especially if the globally desired policy initiative will have no immediate or direct beneficial impact on such pressing domestic problems as increasing unemployment rates, inflation and mounting budgetary and balance of payments deficits. This indicates that international economic interdependence poses a real dilemma for trading nations. Simply put, the dilemma is one of how to enjoy the manifold benefits of interdependence while retaining sufficient national autonomy to use domestic policy instruments to attain desirable domestic economic objectives.

In an effort to resolve this dilemma, some trading nations have established special bilateral trade arrangements, instituted defensive protectionist measures and in some instances have sought the assistance of international financial and trade institutions. Regrettably, some of the macroeconomic and commercial policy responses of several countries are geared not toward facilitating needed secular and cyclical changes, but rather to dampen the adverse effects of change and as a consequence retard the adjustment process. Not infrequently, these macro-economic policy responses are destabilizing, because they create trade distortions - distortions which nullify the competitive leverage afforded by comparative cost advantage.

INSTITUTIONAL ARRANGEMENTS

The problems of interdependence, the need for policy co-ordination among trading nations, and the reconciliation of domestic policy responses from disparate economic systems are readily evident in the 1987 activities of such international institutions as the GATT and UNCTAD. Equally, if not more important for Canada's mineral trade is the Canada-U.S. Free Trade Agreement. Other highlights relate to the Common Fund for Commodities and study groups for nickel and copper.

UNITED NATIONS CONFERENCE ON TRADE AND DEVELOPMENT (UNCTAD)

Every four years (this time in July in Geneva), the world comes together in a north-south context to debate and negotiate - at the ministerial level - the policy and sometimes the institutional ways in which development issues will be approached. It is here that commodities are looked at in the United Nations system, including mineral commodities. As has been the case for several years now, the Latin preoccupation with debt overshadowed the African concern for more basic developmental measures. There were no major initiatives launched for commodities and little that could be construed to have specific relevance to minerals. Rather, the accomplishment of UNCTAD VII was that it avoided sweeping prescriptions, paid appropriate attention to market realities, and above all, suggested a growing willingness on the part of nation states to acknowledge the interdependence of all their economies. For the first time in history, no resolutions were passed: there was a single outcome document which will provide the political and analytical context within which more specific topics will be examined in subsequent years. This should be helpful to Canadian mineral interests.

Common Fund for Commodities

In 1987, the U.S.S.R. first signed (July) and then ratified (December) the Common Fund. It is now inevitable that this institution, which was designed to act as a banker for international commodity agreements such as existed for tin, will fulfil the legal requirements for its entry into force. Those which have ratified the Common Fund (over 100 states, including Canada but not, notably, the United States) will now have to decide how it is to function in practice. The Common Fund itself was the product of the negotiating climate that existed in the mid- to late 1970s. Since then, there have been some lessons learned and significant changes in how a number of governments view attempts to regulate commodity markets. More pertinent to the actual functioning of the Common Fund, there are no longer many commodity agreements in place to make use of its facilities, nor the prospect of many new ones. States which have ratified the Common Fund will be looking at what to do with a bank which now lacks a clientele. One possibility which will be closely examined is to increase the role of the Second Account, that part of the Common Fund which is to assist with commodity-specific research and development and market development projects. This could have particular relevance to commodity study groups.

International Nickel Study Group and International Copper Study Group

While the specific commodity reviews for these two metals will provide the details of developments during 1987 for both of these initiatives, several general observations are appropriate here. While support for market interventionist approaches (as epitomized by the Sixth International Tin Agreement) has never been weaker, support in principle for study groups has probably grown. However, while progress was made in 1987 on both copper and nickel, it remains extremely difficult to translate support in principle into a firm commitment to membership. This is true even though the prospect of commodity product and market development support from the Common Fund has increased (see above) and the Soviet Union has for the first time committed itself to provide statistics in the context of its obligations of membership in the nickel study group. The main constraint is financial (for governments of both developed and developing countries) but there sometimes also arise sensitivities about arguments being made in certain quarters as to liabilities of members of international organizations. This latter issue is much more pointed in light of the difficulties facing the International Tin Agreement and its members who face litigation from creditors arising out of the halt to the economic activities of that Agreement.

Canada-U.S. Free Trade Agreement

On October 4, 1987, Canada and the United States agreed in principle on the elements of a Free Trade Agreement. Prime Minister Mulroney and President Reagan signed the Agreement on January 2, 1988, which upon ratification by the two countries will come into force on January 1, 1989 and be fully implemented over a ten-year period.

The Agreement is a precedent-setting accord between the world's two largest trading partners. It will eliminate bilateral barriers to trade in goals and services, including trade-related investment measures, and establish effective procedures for the joint administration of its provisions and the resolution of disputes. The Agreement builds upon the principles of the General Agreement on Tariffs and Trade (GATT), which has been the cornerstone of Canada's trading relations, and is fully consistent with Canada's multilateral obligations. It should also be noted that during 1987, Canada participated in preliminary talks for another round of Multilateral Trade Negotiations (MTN) launched at Punte de Este, Uruguay in 1986; these negotiations are expected to take about three years.

Canada's minerals and metals industry stands to gain important benefits from the Free Trade Agreement. For the industry as a whole, the most important elements of the Agreement are the dispute settlement mechanism, the elimination of tariffs, and improved rights and obligations on technical standards. Because tariffs tend to increase with the degree of value added, the impacts of the Agreement will be felt more at the processing stage than in mining. While the biggest gains for Canadian producers are expected to be in those commodities such as aluminum, certain ferroalloys, magnesium and zinc that require large amounts of electrical energy in their production process, benefits will accrue to other sectors as well. As well, input costs to the industry, to the extent that they are subject to a tariff, will be deemed as this agreement takes effect.

CONCLUSION

Broadly speaking, the future of Canada's mineral trade depends upon three factors:

- the rate of growth of world demand for minerals and mineral materials;
- the cost competitiveness of the Canadian mineral industry; and
- access to markets.

World consumption of minerals and metals is increasing, albeit at a decreasing rate. In recent years, the industry has gone through a difficult period of supply-side adjustment and should now benefit from this increased demand. By and large, the Canadian mineral industry is cost-competitive. Market access will, however, continue to pose a problem for sometime to come.

In terms of market access, the Government of Canada has moved to secure access to our largest market via the Canada-U.S. Free Trade Agreement. As well, the benefits that accrue from reduced tariff and non-tariff barriers are being pursued on a broad multilateral front via the Uruguay Round of the MTN. The market transparency activities of mineral commodity study groups and the prudence of international financial institutions in their involvement in mineral development and trade should augur well for stability in international mineral commodity markets. And this will certainly enhance Canada's mineral commodity trade.

It is worth noting that on the issue of market access, the outcome of UNCTAD VII is encouraging. UNCTAD VII dealt at length with the potential benefits of the Uruguay Round of Multilateral Trade Negotiations (MTNs) in improving market access. It restated several commitments from the Punte de Este Declaration on "standstill" and "rollback" (of tariffs and trade restrictions) while stressing the growing need for adequate and well co-ordinated policy responses to secular changes. UNCTAD appears, therefore, to be developing a relationship with the GATT based on complementarity.

TABLE 1. CANADA'S MINERAL[1] EXPORTS 1986 AND 1987, BY MAJOR MARKET AND STAGE OF PROCESSING[2]

	1986				1987[3]			
	United States	EEC[4]	Japan	Total	United States	EEC[4]	Japan	Total
				($ million)				
Crude								
Ferrous	508.2	526.8	44.5	1 107.8	383.6	480.9	39.3	928.1
Nonferrous	195.2	403.6	563.7	1 248.2	198.5	493.6	574.3	1 338.1
Industrial	871.5	557.9	1 434.4	4 691.0	836.7	517.2	1 228.9	4 203.3
Total	1 574.9	1 488.3	2 042.6	7 047.0	1 418.8	1 491.7	1 842.5	6 469.5
Scrap								
Ferrous	67.0	15.1	5.0	107.2	81.7	11.6	3.2	123.2
Nonferrous	288.6	93.8	28.4	434.2	336.7	88.4	37.2	494.5
Total	355.6	108.9	33.4	541.4	418.4	100.0	40.4	617.7
Smelted and refined								
Ferrous	174.8	74.0	11.6	278.0	130.7	56.3	6.5	207.1
Nonferrous	6 247.8	884.6	283.5	8 287.9	4 170.8	1 066.5	504.9	6 579.3
Total	6 422.6	958.6	295.1	8 565.9	4 301.5	1 122.8	511.4	6 786.4
Semi-manufactured								
Ferrous	1 976.3	29.1	1.0	2 164.9	2 241.1	13.1	1.3	2 472.7
Nonferrous	658.3	112.9	34.1	865.3	844.4	108.8	36.8	1 069.7
Industrial	926.5	16.8	4.7	996.6	949.3	30.5	6.7	1 043.7
Total	3 561.1	158.8	39.8	4 026.8	4 034.8	152.4	44.8	4 586.1
Grand total (excluding scrap)	11 558.6	2 605.7	2 377.5	19 639.7	9 755.1	2 766.9	2 398.7	17 842.0
Percentage of grand total	58.9	13.3	12.1		54.7	15.5	13.4	

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[1] Includes uranium and coal but excludes petroleum and natural gas. [2] The trade data compiled on the basis of a mineral industry definition developed by the Mineral Policy Sector of EMR in 1977. [3] 1987 estimates based on nine month data. [4] EEC: Belgium, Denmark, France, West Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, United Kingdom and Greece.

TABLE 2. CANADA'S MINERAL[1] IMPORTS 1986 AND 1987, BY MAJOR MARKET AND STAGE OF PROCESSING[2]

	1986				1987[3]			
	United States	EEC[4]	Japan	Total	United States	EEC[4]	Japan	Total
				($ million)				
Crude								
Ferrous	271.1	...	0.1	294.5	220.5	...	-	227.7
Nonferrous	641.1	17.1	-	869.1	325.6	21.7	-	499.7
Industrial	1 041.3	22.0	0.1	1 101.2	901.9	16.0	...	956.8
Total	1 953.5	39.1	0.1	2 264.8	1 448.0	37.7	...	1 684.2
Scrap								
Ferrous	66.0	...	-	66.1	70.8	0.1	-	70.9
Nonferrous	204.8	19.3	0.2	367.6	228.0	11.3	-	346.4
Industrial	1.0	-	-	1.0	1.2	-	-	1.2
Total	271.8	19.3	0.2	434.7	300.0	11.4	-	418.5
Smelted and refined								
Ferrous	71.7	77.7	...	212.0	82.3	134.7	...	302.3
Nonferrous	2 128.0	103.2	63.3	2 672.8	1 274.0	101.9	24.0	1 980.4
Total	2 199.7	180.9	63.3	2 884.8	1 356.3	236.6	24.0	2 282.7
Semi-manufactured								
Ferrous	716.0	482.7	193.3	1 672.3	742.9	463.5	150.7	1 629.5
Nonferrous	774.2	113.7	21.4	960.6	881.5	119.1	19.9	1 067.1
Industrial	986.5	309.1	56.5	1 479.0	1 014.1	350.8	38.8	1 557.5
Total	2 476.7	905.5	271.2	4 111.9	2 638.5	933.4	209.4	4 254.1
Grand total (excluding scrap)	6 629.9	1 125.5	334.6	9 261.5	5 442.8	1 207.7	233.4	8 221.0
Percentage of grand total	71.6	12.2	3.6		66.2	14.7	2.8	

[1] Includes uranium and coal but excludes petroleum and natural gas. [2] The trade data compiled on the basis of a mineral industry definition developed by the Mineral Policy Sector of EMR in 1977. [3] 1987 estimates based on nine month data. [4] EEC: Belgium, Denmark, France, West Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, United Kingdom and Greece.
... Amount too small to be expressed; - Nil.

Regional Review

H.R. WEBSTER

The value of production of metals, nonmetals, structural materials and coal in 1987 was $17.7 billion, an increase of $2.3 billion, or 14.9% over 1986. Metals increased 24.2%, structural materials increased 12.7%, but nonmetals dropped 1.7%, and coal decreased 5.2%. When natural gas, natural gas byproducts and crude petroleum are included, the value of production was $36.0 billion, an increase of 11.0% over 1986.

The Canadian mining industry ended 1987 with guarded optimism that it may finally be emerging from the effects of the 1981 recession. Inventories are down, exploration expenditures are generally at a high level, gold prices are up, nonferrous metals prices have recently started to rise, and the industry is committed to more efficient and competitive operations. However, following the market adjustment in October, the industry is concerned whether current higher price levels will continue in the face of a possible downturn in the economy and whether the ability to raise exploration and development money will be maintained.

The Canada-U.S. Free Trade Agreement is expected to have a positive effect on the mineral industry by enhancing mineral and metal export opportunities.

The federal-provincial Mineral Development Agreements (MDAs) have continued to play an important role as an instrument for regional economic development. The five-year MDAs with Newfoundland, Nova Scotia, New Brunswick, Manitoba and Saskatchewan are progressing well in the fourth year of activity and will expire in March 1989. The three-year MDA with Prince Edward Island and the four-year MDA with the Yukon will also be completed in 1989. Five-year MDAs with British Columbia, Ontario and Quebec will finish in 1990. In July 1987 a four-year $7 million MDA between Canada and the Northwest Territories was signed.

A new federal policy on regional development was initiated during the year with the establishment of regional agencies in Moncton, Sault Ste. Marie and Edmonton to promote economic growth and diversification by putting regional policy and decision making in the regions. The implications of this new policy for the mineral industry's role in regional development are as yet uncertain.

NEWFOUNDLAND

The mineral industry of Newfoundland accounts for about 12% of Gross Provincial Product. In 1987, the value of mineral production decreased 6.1% to $767 million, of which $685 million was iron ore, $21 million asbestos and $17 million zinc.

Exploration activity in the province set new records in 1987; expenditures are estimated at $25 million, up from $15 million in 1986. Claim staking was up over 25%, the number of claims in good standing by more than 30%. After ten years of lacklustre development, Newfoundland is now firmly established in a new era of mining and mineral exploration.

Gold is the driving force behind this high level of activity. Since the Hope Brook gold discovery, numerous new gold occurrences have been found. Hope Brook Gold Inc. poured its first gold bar in August, less than a year after making the decision to go into production. The underground mine is scheduled to start production in October 1988.

Following a significant gold discovery, Noranda Exploration Company, Limited and Galveston Resources Ltd. conducted a major exploration program in the Devil's Cove area, Baie Verte Peninsula. Dolphin Explorations Ltd. is sinking a decline on the Cape Ray gold project for underground exploration.

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Encouraging results from trenching and diamond drilling were obtained by Westfield Minerals Limited and Anglo Dominion Gold Exploration Limited on a stratabound gold mineralized zone in the Little River area, Bay d'Espoir. Many other companies have projects under way in the Baie Verte, White Bay, Notre Dame Bay and Chetwynd areas.

Newfoundland Zinc Mines Limited's 1500 t/d Daniel's Harbour mine on the west coast reopened in late summer. Committed to keeping the mine open for a 15-month period, Teck Corporation, the parent company, is undertaking an aggressive exploration program to delineate additional zinc reserves.

In central Newfoundland, near Millertown, Noranda Exploration Company, Limited and BP Selco Inc. discovered a high-grade polymetallic deposit at Duck Pond. The new discovery may be Newfoundland's next mine.

Despite strikes at the two iron ore mines in Labrador, about 19 Mt was produced, the same quantity as in 1986. No increase in production is foreseen in the near future.

Industrial minerals are an important part of the mineral industry in both Newfoundland and Labrador. Commodities that are produced include asbestos, pyrophyllite, slate, silica, elemental phosphorus, gypsum and dolomite. Several new and interesting deposits are under development. At Cormack, Havelock Processing Ltd. began production in June of agricultural limestone for in-province use. Minworth Ltd.'s fluorspar mine on the Burin Peninsula opened in February. The operation was suspended at year end, awaiting improved markets. Mineral Commodities Limited Group (MCLG) purchased the Baie Verte asbestos mine in August. A $20 million expansion is planned, including a wet milling process which will give much higher recovery rates.

The Newfoundland Resources & Mining Company Limited will develop a limestone quarry and processing facility at Lower Cove on the Port au Port Peninsula. Scheduled to produce aggregate in the fall of 1988, principally for United States markets, this project includes construction of a deep-water shipping facility.

In Labrador, exploration for gold, silver, platinum group metals and columbium-rare earths took place.

Highlights of work done in the geoscience program of the five-year, $22 million Canada-Newfoundland Mineral Development Agreement include: the identification of high-quality silica deposits in the Labrador City area; evaluation of dolomite and marble deposits in western Newfoundland; regional mapping in both Newfoundland and Labrador; and the geochemical definition of new areas of gold potential on the Baie Verte Peninsula.

Under the economic development program, several deposits of building stone are being assessed for quality and commercial potential. The program has also provided funds to the Labrador Inuit Development Corporation for the promotion of labradorite. This ornamental-quality stone occurs in the Nain area, on the northern Labrador coast.

The evaluation of the Point Leamington base-metal deposit was completed under the mining and minerals technology program. The evaluation of aggregates for potential alkali-reactivity continues.

The provincial government will implement a Newfoundland Stock Savings Plan in 1988 to encourage direct investment by Newfoundlanders in their own province. One aim of the Plan is to encourage a junior mining industry in Newfoundland to develop mineral properties.

NOVA SCOTIA

In 1987, the value of mineral production in Nova Scotia increased by 6.4% over 1986 to $390 million, of which $171 million was for coal and $51 million for gypsum.

The five-year Canada-Nova Scotia Mineral Development Agreement (MDA) entered its fourth year. The Mineral Investment Stimulation Program (MISP), introduced by amendment to the MDA in 1985, has to date sponsored 23 projects, on a 50-50 basis with eligible individuals and corporations to improve the economic viability of their operations through investigations of established deposits, mineral processing studies, and market and productivity studies. The program has been well received by industry, and results to date have been encouraging.

More than $50 million was spent by industry on exploration in 1987. This record expenditure was up considerably from the 1986 estimate of $25 million and resulted largely from flow-through share funding, renewed interest in gold exploration in Nova Scotia, and an increase in geologic data resulting from MDA projects. Gold exploration was concentrated in the southern mainland and accounted for an estimated 85% to 95% of exploration expenditures.

Seabright Resources Inc. marked Nova Scotia's return to a gold-producing province in June 1987 with the pouring of a gold bar at its newly-renovated Gays River mill, using development ore trucked from the Forest Hill mine in Guysborough County. Production is also anticipated at Seabright's Beaver Dam, Caribou and Moose River properties.

Coxheath Gold Holdings Limited spent close to $10 million on exploration at its Tangier, Halifax County, gold property. The extensive underground development program led to establishment of on-site mill and assay facilities. A production decision is expected early in 1988.

Pan East Resources Inc. continued a drilling program on its Fifteen Mile Stream gold property, 150 km northeast of Halifax. NovaGold Resources Incorporated reached the bulk sampling stage on its Fifteen Mile Stream gold property in the fall of 1987, and a production decision is anticipated in 1988. Acadia Mineral Ventures Limited continued a drilling program on its Mooseland gold property in Halifax County. Scominex continued its regional gold exploration program in the Cape Breton Highlands.

The East Kemptville tin mine, in Yarmouth County, was operated throughout 1987 by the consortium of banks led by the Bank of America/Canada that had initially financed the project. It was learned at year-end that Rio Algom Limited had signed a letter of intent to buy the mine back from the banking consortium.

Georgia-Pacific Corporation is producing from the River Denys gypsum quarry as well as the newly-opened Sugar Camp gypsum quarry in Inverness County. The product is trucked to the Strait of Canso for shipment to company-owned wallboard plants in the eastern United States. Little Narrows Gypsum Company Limited opened a new gypsum quarry, the McAuley, in Inverness County. All material is shipped through the Little Narrows facilities. National Gypsum (Canada) Ltd. at Milford and Fundy Gypsum Company Limited at Wentworth and Miller Creek operated throughout the year.

Mosher Limestone Company Limited produced dolomite at Kellys Cove, Victoria County, for agricultural stone and stone dust. The company continues to investigate the development of a quarry, and crushing and shipping facilities to supply high-quality granitic aggregate to United States markets.

The two producing salt companies, The Canadian Salt Company Limited at Pugwash and Domtar Inc. at Nappan, operated throughout 1987. The vapour recompression evaporation plant installed by Domtar Chemicals Group, a division of Domtar Inc. at its Nappan salt mine was officially opened in October 1986 allowing the operation to continue production well into the next century. Total energy requirement from oil and electricity has been cut by 71%. Since the plant is now more dependent on electrical energy, dependence on offshore oil has been reduced by 90%.

Nova Scotia coal production increased in 1987 with the opening of the Cape Breton Development Corporation's (CBDC) Phalen mine at Lingan on Cape Breton Island. With plant expansion, modernization of rail and port facilities, the purchase of new equipment and application of new technology, the CBDC coal operations compare favourably with underground coal operations in other parts of the world. The bulk of Nova Scotia coal is used in provincial generating stations.

NEW BRUNSWICK

In 1987, the value of mineral production in New Brunswick increased over that of 1986 by 39.7% to $701 million. Zinc, with an increase of 50%, accounted for $295 million. Lead accounted for $84 million and silver $62 million. The increase in the value of production of industrial minerals was mainly due to potash.

The mining industry continued to play a vital role in New Brunswick's growth and development. The number of claims recorded during 1987 approached 3 800, up from 2 600 in 1986. Exploration expenditures increased from $3 million in 1986 to approximately $12 million in 1987.

The five-year, $22.3 million Canada-New Brunswick Mineral Development Agreement (MDA) completed its third year on March 31, 1987. At that date, nearly $8.4 million had been spent, with some 65% having been expended on geoscientific projects and the balance primarily on mining and processing technologies and economic development studies. The Mineral Investment Stimulation Program (MISP), a $1 million program introduced by amendment to the MDA in 1986, has funded thirteen projects to date. The program is designed to stimulate private sector investment in the development of the mineral industry in New Brunswick by offering a 50-50 participation by industry and government in specified projects such as further characterization of established deposits, processing research and development, and marketing of mineral commodities. The $400 000 Mineral Processing Investigations Program (MPIP), introduced under the MDA at the same time as the MISP, now supports six projects. Investigations under MPIP focus on laboratory testing to characterize ore deposits and studies of alternative processing methods.

Gordex Minerals Limited carried out a $2.5 million expansion on the open-pit Cape Spencer gold property. The gold-extraction process was changed from a zinc precipitate to a carbon pulp extraction, and the operation was modified from a heap-leach treatment to an earthen vat system. Production is estimated at 233 kg of gold for 1987 and is expected to increase to 342 kg in 1988. Necessary approval regarding environmental issues was received, and the company resumed production in August 1987.

Northumberland Mines Limited plans a gold-silver vat leaching operation at the gossan-type open-pit deposit at Murray Brook in northeastern New Brunswick. Construction could begin in 1988, with production before year-end.

Production at the Lake George antimony mine of Durham Resources Inc. (now Landmark Corporation) continued through 1987. Several MISP studies were carried out at the property.

Lac Minerals Ltd. continued surface and underground exploration on its tin prospect near the Mount Pleasant tungsten mine, which closed in 1985 as a result of oversupply, a drop in the price of tungsten and beneficiation problems. Beneficiation studies are being carried out under the MPIP on the tungsten ore of the Mount Pleasant mine, to investigate the recovery of fluorite, rare earths and base metal sulphides, as well as tungsten.

Based on the results of a project funded by the MDA and carried out by Heath Steele Mines Limited and the University of New Brunswick, a $4 million underground exploration program on the Stratmat Boundary property is being undertaken by the Noranda Group. The program involves driving a 1432 m decline and bulk sampling 1000 to 2000 t of ore for metallurgical testing. If sufficient and satisfactory ore is proven, an open-pit operation to 200 feet could be undertaken.

The two producing potash mines near Sussex, operated by Potash Company of America, Inc. (PCA) and Denison-Potacan Potash Company, increased production during 1987. Underground and surface exploration continued at the Millstream potash deposit of BP Resources Canada Limited, near Sussex.

Brunswick Mining and Smelting Corporation Limited has shown continuous profit at its Bathurst lead-zinc-silver operation since the last quarter of 1986, the result of cost-cutting measures taken by the company, firm lead markets and improved silver prices.

Fifteen peat bogs were in production during 1987, and several others are at the development stage. A peat market study and a technical study on the agricultural use of peat were completed under the MDA.

The mill building and starter dam were constructed at Caribou New Brunswick Mining Limited's property near Bathurst. With acceptance of a reclamation plan, issuance of a mining lease is expected early in 1988. Production is anticipated by June 1988 to produce a bulk lead-zinc concentrate for shipment to AM&S Europe Ltd. in Avonmouth, England.

QUEBEC

In 1987 the value of mineral production in Quebec reached a record level of $2.5 billion, an increase of 15.4% over 1986. This major increase is mainly attributable to higher gold prices. The value of gold production increased by more than $90 million to $556 million. The value of zinc production increased by $73.6 million over 1986 to $118.7 million, a rise of 163%. Production of other commodities such as silver, cement and stone also showed significant increases.

The Canada-Quebec Mineral Development Agreement (MDA) is now in its third year. A major achievement this year was the completion of a road link between Manic V and Gagnon to open up the iron ore producing region of Fermont-Labrador City-Wabush. In addition to opening up vast areas for mineral exploration, the new road provides the population of that isolated area with access to the Quebec highway network.

Employment levels were up from last year's total of 20 162 to 21 075.

Exploration expenditures in Quebec reached record levels in 1987, totalling nearly $500 million, an increase of more than 90% over the 1986 total of $263 million. The flow-through share tax provision was the main factor in this increase. Expenditures in the Abitibi-Témiscamingue region represented over 85% of the total.

In the Abitibi-Témiscamingue region many new mines came into production, the most important being the copper-silver-zinc Selbaie mine in Joutel. Production at Minnova Inc.'s Ansil project is expected in the spring of 1988.

On April 22, 1987 INCO Limited and its partner, Golden Knight Resources Inc., announced the start of development of their Golden Pond East gold deposit in Casa Berardi Township. Assistance was provided under the MDA to offset infrastructure costs allowing access to the isolated area.

On April 1, 1987 a fire at Gaspé Mines in Murdochville led to a decision by Noranda Minerals Inc. to suspend mining operations indefinitely. Approximately 420 workers were laid off. However, smelter operations at Murdochville are continuing, employing some 300 workers.

A four-year $5.5 million Prospectors Assistance Program in the Gaspé, funded jointly under the federal government's Eastern Quebec Development Plan and the Province of Quebec was started in 1987. The program provided assistance and support to individual prospectors and to exploration companies. Some interesting mineral occurrences were discovered as a result of the work carried out by more than 80 prospectors participating in the program.

The asbestos industry continued to deteriorate in 1987 due to lower demand for asbestos fibre. In October LAB Chrysotile Inc. announced the lay-off of 450 workers following the decision to close the Bell mine indefinitely. Close to 5000 asbestos workers in the region have lost their jobs over the last ten years. To boost the demand for asbestos fibre, $11 million was allocated to the Asbestos Institute to carry out research on new uses for asbestos: $8 million was provided under the MDA and $3 million by industry.

Iron ore production increased to 15.5 Mt, an increase of 2 Mt over 1986. Markets and prices were particularly attractive for iron ore pellets.

The new Quebec Mining Law adopted by the National Assembly on June 23, 1987 will become effective in the spring of 1988.

ONTARIO

In 1987, the value of mineral production in Ontario increased over 16% to $5.6 billion. Metals and nonmetals accounted for 77% of this value and structural materials for 21%. Gold ranked first with an estimated value of $1.03 billion, followed by nickel at $902 million, copper at $675 million and uranium at $509 million. These four minerals accounted for over 55% of the value of mineral production, although the Ontario mining industry is very diverse, producing more than 60 different minerals.

Much of the exploration work in Ontario during 1987 was related to gold. New and previously known properties were examined and producing mines expanded.

At Red Lake, both Placer Dome Inc. and Dickenson Mines Limited are currently undergoing expansion programs. The Detour Lake mine will reach full production from underground in mid-1988. Emerald Lake Resources Inc.'s Golden Rose and Canamax Resources Inc.'s Bell Creek gold properties began producing. Many gold deposits are forecast to come on stream before 1990. These include St. Joe Canada Inc.'s Golden Patricia and the Dona Lake project of Placer Dome Inc. in the Pickle Lake area; American Barrick Resources Corporation's Holt-McDermott mine at Kirkland Lake; and St. Andrew Goldfields Ltd.'s project near Timmins. Extensive development work, including test milling, is being done in most of the old gold camps and in many new areas.

In the Sudbury area, INCO Limited reopened the Crean Hill nickel mine in 1987, its first all-electric mine. Falconbridge Limited has made a new base and precious metals discovery in Blezard township. Near Schreiber, Minnova Inc.'s Winston Lake mine will begin zinc-copper-silver-gold production early in 1988.

Production is imminent at Cobalt where the Hellens-Eplett silver mine of Silverside Resources Inc. and International Platinum Corporation is in the final construction phase. Agnico-Eagle Mines Limited is sinking a new production shaft on the Langis property, and the new Penn mill began operating in June 1987.

In central Ontario, near Huntsville, Cal Graphite Corporation plans to process graphite ore by September 1988. Princeton Resources Corporation is operating a pilot plant at the Bissett Creek graphite deposit. In southwestern Ontario, Domtar Inc. plans full production at the underground gypsum mine at Caledonia in 1990. The deposit is 2 km from the wallboard plant.

The uranium mines at Elliot Lake continue to produce 40% of Canada's uranium. Ontario Hydro takes a large part of the output.

Production from the three iron ore mines in northern Ontario totalled about 3 300 t in 1988. The mines are owned and operated by the steel producers, The Algoma Steel Corporation, Limited and Dofasco Inc.

During 1987, the five-year $30 million Canada-Ontario Mineral Development Agreement entered its third year. Outputs from the geoscience program now available to the exploration industry include maps, mineral deposit studies and geophysical and geochemical surveys. The productivity and technology program has made excellent progress on the development of dense fill in bulk mining and computer modelling of underground stress patterns. These projects are being carried out in mines at Sudbury, Timmins and Elliot Lake and are expected to help companies significantly reduce mining costs and increase productivity while maintaining or improving safety. Economic development studies under way on whitewares, building products, glassware and advanced materials technology are aimed at increasing the use in Ontario of the province's industrial minerals.

MANITOBA

In 1987, the value of Manitoba's mineral production increased by 33.8% over 1986 to $1.02 billion, of which $386 million was for nickel, $173 million for copper, and $84 million for zinc.

The five-year $24.7 million Canada-Manitoba Mineral Development Agreement (MDA) entered its fourth year. The MDA is contributing to regional economic development through: geological mapping and other geoscientific programs to provide industry with information required to explore for mineral deposits; technology research to help improve worker safety and productivity at mining operations; and market development and commodity studies to identify new mineral resource development opportunities.

Mining provides the principal economic base for the northern communities of Manitoba. Low metal prices and declining ore reserves and grades since 1982 caused intermittent mine closures and the layoff of hundreds of employees. The existence of several communities, in particular Lynn Lake and Leaf Rapids, has been threatened. In response, government and industry have taken measures to discover and develop new mineral deposits and reduce production costs at existing mines. These initiatives have contributed to increased exploration and development expenditures of approximately $30 million in 1987.

At Lynn Lake, the new MacLellan gold mine of SherrGold Inc. reached full production in 1987. Near Leaf Rapids, Sherritt Gordon Mines Limited substantially reduced production costs and increased ore reserves at its Ruttan mine. The mine was sold in July to Hudson Bay Mining and Smelting Co., Limited (HBM&S), and will be amalgamated into the company's northern Manitoba operations. The provincial government and HBM&S will each spend $500 000 in the search for further reserves.

In the Flin Flon area, a new gold mine was opened at Tartan Lake, a nickel-copper mine is being developed at Namew Lake and at Puffy Lake a new gold mine was brought into production. Exploration is active on several other gold and base metal deposits. In the Snow Lake area, major zinc and precious metal finds are being explored at

Morgan Lake. In the Lynn Lake area, widespread gold mineralization is being explored at various locations, including Farley Lake, Wasekwan Lake and Lynn Lake.

Job security and the long-term viability of the Thompson nickel mining and smelting operations of INCO Limited have improved, as a result of previous efforts to lower operating costs and strengthening metal prices.

Near Bissett an underground exploration program at the San Antonio gold mine, closed since May 1983, indicates that a viable operation is possible. Near Lac du Bonnet, approximately 50 new full-time jobs will be created when Tantalum Mining Corporation of Canada Limited (TANCO) resumes production of tantalum at its Bernic Lake mine in mid-1988 and completes construction of its spodumene concentrator.

The Government of Manitoba and Canamax Resources Inc. announced in November that a feasibility study has confirmed excellent reserves and grades of potash near Russell, and that market demand would support a mine by the early 1990s. The partners are attempting to interest foreign governments, such as China and India, in providing equity investment and markets.

SASKATCHEWAN

In 1987, the value of mineral production increased by 19% over 1986 to $3.0 billion. The principal commodities after the petroleum industry are uranium at $611 million and potash.

In northern Saskatchewan, exploration expenditures in 1987 for gold and other precious metals were approximately $35 million; much of this exploration was along the greenstone belt northeast of La Ronge. Among the most promising deposits are those located at Waddy Lake, Laonil Lake, Sulphide Lake, Mallard Lake and Fork Lake. At Star Lake, Saskatchewan Mining Development Corporation (SMDC) and partners initiated production at their 220 t/d gold mine early in 1987. North of Lake Athabasca in the Beaverlodge area, gold and platinum group mineralization was discovered, known uranium showings are being investigated for precious metal potential, and the former Box gold mine is being evaluated.

In the Athabasca Basin, uranium exploration expenditures are expected to be $18 million despite the continued low price for uranium. Cigar Lake Mining Corporation was granted approval in October to proceed with a $40 million project to test methods for mining this uniquely rich deposit. If the tests prove successful, production could begin in 1993 at a rate of 4600 tU annually. Eldorado Resources Limited is seeking regulatory approval to develop the Collins Bay A and D orebodies and to initiate underground exploration and test mining of the Eagle Point deposits as a future source of ore for the Rabbit Lake concentrator.

At Cluff Lake on the western side of the Athabasca Basin, Cluff Mining began producing gold and uranium in March at its processing facility, which was modified to reprocess radioactive residues produced during the initial years of the operation. Primary uranium production is from the Claude open-pit mine and the Dominique-Peter underground mine. Other zones are being explored for future development.

On the southeast edge of the Athabasca Basin, Key Lake Mining Corporation is preparing the Deilmann orebody for mining in mid-1988 to replace the stockpiled ore from the Gaertner orebody, which was depleted in 1986. During the summer, the company conducted a 10 000 t heap-leach test to verify uranium extraction capability from stockpiled low-grade ores; a 100 000 t leach facility was planned for possible operation in 1988.

Prospects for the uranium industry improved with the announcement in October of the proposed Canada-U.S. Free Trade Agreement. The agreement eliminates the threat of U.S. court or legislative action which could restrict imports of Canadian uranium for enrichment and domestic use.

In late December, the federal government announced relaxation of its foreign ownership restrictions in the uranium sector. The new policy specifies that Canadians must own at least 51% of an individual uranium property when it comes into production, although a lesser level of ownership may be permitted if the project is controlled by Canadians or if no Canadian partners can be found.

Water infiltration in several Saskatchewan potash mines continued to be a problem during 1987, the most serious being at the K-2 mine of International Minerals & Chemical Corporation (Canada) Limited (IMCC). Potash Company of America, Inc.'s mine near Patience Lake was forced to shut down in

February for an indefinite period. A pilot project is to begin in 1988 to test the feasibility of converting to a solution mining operation.

Potash sales remained low during much of 1987 as a result of low prices and shipments causing mines to operate at much below capacity and necessitating intermittent layoffs. As a result of efforts by Canpotex Limited, The Potash & Phosphate Institute of Canada and other agencies, offshore sales of potash to China, Japan, Korea, Indonesia and Malaysia have increased. This market diversification has reduced the dependence on U.S. markets from about 70% of total sales during the 1970s to currently about 60%.

In February 1987, two U.S. potash producers filed an anti-dumping complaint against Canadian potash exporters that led to a U.S. Department of Commerce (DOC) preliminary determination of dumping in August which resulted in dumping margins ranging from 9.1 to 85.2%. The case was resolved with a January 7, 1988 signing of a suspension agreement between the potash exporters and DOC.

The five-year, $6.38 million Canada-Saskatchewan Mineral Development Agreement (MDA) entered its fourth year. Geoscientific activities included geological mapping, airborne gradiometric surveys and lake sediment sampling. Studies were conducted to improve the separation of potash from ore and enhance the quality of potash products. Several sites were studied to determine their potential as a source of building stone, a map of local aggregate resources was produced and a brochure was prepared to promote potash in Pacific Rim countries.

ALBERTA

In 1987, the value of mineral production in Alberta was up by 5.0% to $17.1 billion. Of this amount, $605 million was sulphur and $396 million coal.

During 1987, the coal industry has been relatively static and the outlook is for continued stability. A number of communities, including Grande Cache, Edson and Hinton, continue to rely on coal for their economic base. There have been no new projects announced during the year.

Mines supplying coal for domestic electric power generation continue to produce at near full capacity. A new mine is being constructed at Genesee, west of Edmonton, to feed the nearby electric power generating station of Edmonton Power, which is under construction.

In an attempt to increase the use of western Canadian coal in Ontario, an Action Committee on Low-Sulphur Canadian Coal was established in March with Deputy Prime Minister Donald Mazankowski as chairman, Ontario Premier David Peterson as vice-chairman, and the premiers of Saskatchewan, Alberta and British Columbia as members.

Alberta's other major non-petroleum mineral commodity is elemental sulphur, which is produced as a by-product of sour natural gas. Shipments of sulphur have remained about the same as in 1986, but the rate of remelt of sulphur inventories has declined. This will extend the life of the Canadian vatted stocks. About 29 000 jobs can be attributed directly and indirectly to sulphur in Alberta. Eighty percent of the Alberta production is exported through the Port of Vancouver making Alberta a major supplier in the world merchant sulphur market.

BRITISH COLUMBIA

In 1987 the value of British Columbia's mineral production was $3.43 billion, up 8.5% from 1986. Of this amount, $924 million was for coal, $837 million for copper, and $227 million for gold.

Exploration expenditures reached record levels during 1987 as indicated by the B.C. and Yukon Chamber of Mines preliminary estimate of over $130 million for metals exploration alone. This is up 43% from 1986 and surpasses the previous record of $113 million spent on metals exploration in 1981.

Early in the year, a Mineral Industry Task Force, formed at the request of Premier William Vander Zalm and Mines Minister Jack Davis in the fall of 1986, reported on the state of the mineral industry in the province. The provincial government responded in part by increasing its commitment to geoscience investigations by $2 million per year and continuing the Financial Assistance for Mineral Exploration (FAME) program through 1987. The province is continuing to study the Task Force's recommendations, particularly in the area of mining and exploration incentives.

Gold continued to dominate the development scene in British Columbia with production from Mascot Gold Mines Limited's Nickel Plate mine near Hedley starting in April. Properties with production starts scheduled for 1988 and 1989 are Energex Minerals Ltd.'s Al property; North American Metals Corp.'s Golden Bear project; Teeshin Resources Ltd.'s Dome Mountain property; Westmin Resources Limited's British Silbak Premier and Big Missouri properties; Candorado Mines Ltd.'s Hedley gold tailings project; Newhawk Gold Mines Ltd.'s Sulphurets gold-silver property; Northair Mines Ltd.'s Willa gold property; Houston Metals Corporation's Silver Queen silver property; Minnova Inc.'s Samatosum silver property; Levon Resources Ltd. and Veronex Resources Ltd.'s Congress gold property; and City Resources (Canada) Limited's Cenola gold property. At the end of the year Cassiar Mining Corporation made a decision in principle to proceed with the development of the McDame asbestos deposit, which will sustain the town of Cassiar after the depletion of the current Cassiar open pit.

In 1987, the Highland Valley Copper mine, formed by a partnership agreement of Lornex Mining Corporation Ltd. and Cominco Ltd., became operational. At 120 000 t/d, this operation is now by far the largest single metal mine in Canada.

With the removal of the seven-year moratorium on uranium mining and exploration in February, new uranium regulations were put in place. However, there was no activity on any uranium property in 1987, and none is expected in 1988.

Activity under the five-year, $10 million Canada-British Columbia Mineral Development Agreement (MDA) continued at full strength in 1987. The success of the MDA, based on the results of the first two years, seems assured and is out of proportion with the modest amounts of money being spent on it.

NORTHERN CANADA

The value of mineral production in the Northwest Territories in 1987 was $950.1 million, up 20.5% from 1986. Exploration expenditures were estimated by the Department of Indian Affairs and Northern Development (DIAND) to be up by about $35 million over last year, at about $69 million.

In the Yukon, production from the Faro mine increased during the year as the mine approached its rated production capacity. The Mount Skukum gold property became the Yukon's first major lode gold producer. Reported gold production from placer mining was nearly 4100 kg, the highest since 1917. As a result, the value of mineral production in the Yukon increased 153.9% from 1986, for a 1987 value of $447.2 million. Exploration expenditures reached a near record level of $40 to $45 million, up from $32 million in 1986.

In the Northwest Territories, Pine Point Mines Limited stopped mining at the end of June. The mill will continue to produce concentrate from stockpiled ore until March 1988. Shipment of concentrate is expected to continue until the end of 1988.

The Minister of Indian Affairs and Northern Development announced a revised Comprehensive Land Claims Policy, which was approved by Cabinet in December 1986. The revised policy contains provisions for new approaches to the cession and surrender of title, self-government, wildlife and environmental management, the inclusion of offshore areas in negotiations, resource revenue sharing and negotiating procedures. Cabinet approved negotiating mandates for the Council of Yukon Indians (CYI) Claim and the Dene/Metis Claim during the spring and the Tungavik Federation of Nunavut (TFN) Claim in December. Several policy revisions, including a commitment to consult with third parties, are of interest to the mining industry.

In the Yukon, claims negotiations have resumed on a band-by-band basis. The allowable land quantum has been slightly enlarged (by about 15%) and bands that had not made a selection at the time of the 1984 Agreement in Principle are being urged to do so. The bands have protested to the Minister of Indian Affairs and Northern Development that an upsurge in claim staking activity in the Yukon is encumbering land in which they have an interest. The claim staking, which the CYI blames on DIAND's Northern Mineral Policy, is more likely a response to the funds that were made available in 1986 and 1987 by the favourable tax treatment given to flow-through shares.

In the Northwest Territories, the Dene/Metis claim negotiations have proceeded to the stage of initial land selection. The TFN claim, which was not as far advanced as the others when the revised policy was released, has made less progress than the others because of the need to develop a negotiating mandate.

The Land Use Planning Process now under way in the Northwest Territories will produce a first draft of the land use plan for the Lancaster Sound Region. The draft is to be presented to the Minister of Indian Affairs and Northern Development imminently. A Regional Commission for the Beaufort Sea-Mackenzie Delta has been appointed. Establishment of a third commission to begin work in the Mackenzie Valley has been discussed. An agreement to implement a land use planning program in the Yukon was signed by the federal and territorial governments in the fall of 1987.

In the Yukon, consultations involving the Department of Fisheries and Oceans, DIAND and the Klondike Placer Miners Association (KPMA) to establish a regulatory regime for water use acceptable to all parties have made considerable progress, but problems involving standards for suspended sediment have not yet been resolved.

Using funding provided by Energy, Mines and Resources Canada (EMR) through the Canada Centre for Mineral and Energy Technology (CANMET) and the Industrial Research Assistance Program (IRAP) of the National Research Council of Canada, the KPMA began a project to develop a sampling system to determine the amount of fine gold in placer gravels that is not being recovered by current sluice box methods and to investigate the feasibility of establishing a placer mining research laboratory in Whitehorse.

The Canada-Yukon Mineral Development Agreement completed its third of four field seasons. Detailed mapping was done in the Rancheria and Whitehorse areas and begun in the East and West Dawson Range. Other projects included laboratory research on heap leaching, field trials of new placer mining technologies and geochemical sampling under the aegis of EMR for completion of a west Yukon geochemical map.

On April 30, 1987, the Canada-Northwest Territories Economic Development Agreement (EDA) was extended and includes for the first time a Mineral Development Agreement (MDA) which was approved by the federal government and the Government of the Northwest Territories on July 17, 1987. The new $7 million, four year MDA provides $5.7 million for geoscience, $1 million for a Northern Technology Assistance Program and $300 000 for a Northern Mining Information Program.

LEADING MINERALS IN THE PROVINCES, TERRITORIES AND CANADA: 1986 AND 1987

	Value of Production			
	1986^f	1987P	Change 1987/1986	Proportion of Provincial Total
	($ million)		(percent)	
Newfoundland				
Iron ore	761.3	685.4	-10.0	89.3
Asbestos	16.4	21.0	28.4	2.7
Zinc	6.9	17.0	145.2	2.2
Stone, sand and gravel	13.8	16.2	17.2	2.1
Total	817.3	767.8	-6.1	
Prince Edward Island				
Sand and gravel	1.8	1.9	9.3	100.0
Total	1.8	1.9	9.3	
Nova Scotia				
Coal	177.9	170.7	-4.1	43.8
Gypsum	50.1	51.0	1.8	13.1
Stone, sand and gravel	44.0	48.7	10.7	12.5
Cement	25.4	39.5	55.4	10.1
Salt	x	x	x	x
Tin	x	x	x	x
Total	366.7	390.1	6.4	
New Brunswick				
Zinc	196.6	294.8	50.0	42.1
Potash	x	x	x	x
Lead	45.3	84.0	85.2	12.0
Silver	41.2	62.2	51.2	8.9
Coal	28.0	32.8	17.1	4.7
Total	501.6	700.7	39.7	
Quebec				
Gold	465.3	555.8	19.5	22.0
Iron Ore	x	x	x	x
Cement	190.3	216.9	14.0	8.6
Stone	172.2	189.6	10.1	7.5
Total	2 190.5	2 527.8	15.4	
Ontario				
Gold	759.8	1 029.2	35.5	18.2
Nickel	731.4	902.4	23.4	16.0
Copper	540.9	674.6	24.7	11.9
Uranium	566.1	509.2	-10.1	9.0
Cement	343.1	413.7	20.6	7.3
Total	4 824.7	5 656.6	17.2	
Manitoba				
Nickel	247.7	386.1	55.9	37.8
Copper	133.5	172.6	29.3	16.9
Crude petroleum	95.3	112.8	18.3	11.0
Zinc	74.7	84.3	12.9	8.2
Gold	42.0	71.4	70.3	7.0
Total	763.9	1 022.5	33.9	

LEADING MINERALS IN THE PROVINCES, TERRITORIES AND CANADA: 1986 AND 1987 (continued)

	Value of Production			
	1986^f	1987^P	Change 1987/1986	Proportion of Provincial Total
	($ million)		(percent)	
Saskatchewan				
Crude petroleum	1 172.4	1 417.5	20.9	47.3
Uranium	476.2	611.9	28.5	20.4
Potash	x	x	x	x
Total	2 524.6	2 996.8	18.7	
Alberta				
Crude petroleum	7 978.2	10 003.9	25.4	58.3
Natural gas	5 048.9	3 843.6	-23.9	22.4
Natural gas by-products	1 743.6	1 956.0	12.2	11.4
Sulphur, elemental	804.0	604.8	-24.8	3.5
Total	16 330.5	17 148.1	5.0	
British Columbia				
Coal	973.8	923.8	-5.1	26.9
Copper	626.6	837.2	33.6	24.4
Crude petroleum	245.3	312.9	27.5	9.1
Natural gas	366.2	292.6	-20.1	8.5
Gold	151.8	227.0	49.5	6.6
Total	3 161.3	3 429.0	8.5	
Yukon				
Zinc	61.5	196.8	220.0	44.0
Lead	23.9	106.0	343.6	23.7
Gold	58.2	97.2	66.9	21.7
Silver	18.5	39.7	115.2	8.9
Total	176.1	447.2	153.9	
Northwest Territories				
Zinc	322.1	417.4	29.6	43.9
Gold	205.3	224.8	9.5	23.7
Lead	91.1	142.2	56.0	15.0
Crude petroleum	103.3	126.2	22.2	13.3
Total	788.3	950.1	20.5	
Canada				
Crude petroleum	9 611.8	11 992.7	24.8	33.3
Natural gas	5 623.1	4 310.7	-23.3	12.0
Gold	1 689.3	2 242.9	32.8	6.2
Natural gas by-products	1 802.5	2 016.9	11.9	5.6
Copper	1 426.4	1 844.6	29.3	5.1
Zinc	1 200.6	1 693.7	41.1	4.7
Coal	1 725.9	1 635.0	-5.3	4.5
Nickel	979.1	1 288.5	31.6	3.6
Iron ore	1 342.7	1 254.2	-6.6	3.5
Uranium	1 042.3	1 121.1	7.6	3.1
Total	32 447.3	36 038.6	11.1	

^{f} Final; ^{P} Preliminary; x Confidential.

Labour and Employment

G. KENDALL

OVERVIEW

This is the first year that a separate chapter on labour and human affairs issues has been included in the "Canadian Minerals Yearbook". Therefore, special attention has been paid to putting the analysis of current developments into a broader historical perspective. This chapter includes a review of labour market developments in the mining sector, in addition to an overview of the industrial relations scene and safety and health highlights. Major legislative developments at the federal level are also noted.

At its peak in 1980, mining in Canada (Stages I and II excluding oil and gas) employed approximately 196 000 persons.[1] Forecasted direct employment in the sector for 1987 was 149 000 jobs, a decline of 24% over the decade. In recent years the industry has provided between 1.2-2.0% of domestic employment, exclusive of the considerable number of indirect jobs which it creates. Average earnings in mining are among the highest of all industrial classifications. For 1986 (the most recent year for which complete data are available) average weekly earnings for hourly paid and salaried employees combined were $693.76 for metal mines and $617.66 for the nonmetals, in contrast to $504.10 in manufacturing and $509.86 in construction.

Historically, mining industries have had a reputation for having a relatively poor safety and health record. While the safety and health risks in mining are very real, the record in Canada has shown strong improvement. As an example, in the immediate post-war period, mining **fatalities** (including oil and gas) averaged 2.3-2.4 per thousand paid workers. Rates have fallen steadily since then, to the point where the average for the 1980s is 0.79 per thousand. The preliminary rate for 1986 was 0.54. Unfortunately, in 1987 there was a sharp increase in the number of mining fatalities in Ontario as 17 workers lost their lives in mining accidents. However, the number of **injuries** across the country appears to be decreasing.

As in other sectors, the industrial relations record in the mining sector varies widely over time and is closely correlated with general economic conditions. The mining industry is relatively highly unionized, with the predominant union being the United Steelworkers of America. It is estimated that some 55-60% of mine employees are represented by unions, compared to a national rate of 37% of the non-agricultural paid workforce. The industry has experienced some long and bitter labour disputes, but since the 1982 recession the number of disputes has been sharply down. In fact, the number of disputes has been lower in the last five years than during any period since the statistics were first published in the "Minerals Yearbook" in 1964. It is also important to remember that the vast majority of contracts are signed without a work stoppage. In fact, in 1986 person-days lost due to disputes in mining totalled only about 1.7% of the total work time of unionized workers.

The legislative jurisdiction for most labour matters affecting the mining industry lies largely with the provinces. This includes safety and health, industrial relations, and conditions of work. While there is a broad range of labour legislation across Canada, specific provisions vary widely across the jurisdictions.

LABOUR MARKET DEVELOPMENTS

Because the demand for labour is a derived demand, developments on the demand side of the mining labour market are a function of developments in commodity markets. Consequently, it is predictable that gold is the only commodity where there was employment growth in 1987. Gold mining employment was forecasted to grow to 8900 for 1987 (an increase of 2.8% over 1986),

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[1] Stage I is defined as the sum of metal mines, nonmetal mines, structural materials and coal. Stage II is defined as smelting and refining plus iron and steel mills.

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continuing a virtually steady increase that began in the late 1970s. Significant drops in employment were forecast in iron mining and asbestos for 1987. Employment in the other metals and nonmetals is stabilizing after several years of decreases due to the recession and subsequent rationalizing in the industry.

Consistent with the general strengthening of the economy, and construction in particular, industrial minerals employment has shown strong employment growth. Forecasted 1987 employment in sand and gravel was 2900, up 123% from just three years ago.

Overall, Stage I employment, forecasted to be 76 000 in 1987, appears to be stabilizing after six years of decreases. Stage II employment (i.e. primary metals), estimated at 73 000 for 1987, did not show a similar bottoming-out, and was down 3.5% from 1986.

As Figure 1 shows, mining provides employment in all regions of Canada. As of 1985 (the most recent year for which regional employment data are available from the Annual Census of Mines), approximately 24 400 workers were employed in Stage I mining in Ontario (32%) and 15 400 in Quebec (20%). Sixteen percent of mining employment is in British Columbia, 17% in the Prairie Provinces, and the remainder in the North and Atlantic regions. Stage II employment is more concentrated with 85% located in Ontario and Quebec.

On the supply side, the national labour force has been growing at a rate of about 1.8% during the 1980s, and the 1987 participation rate (January to October) was 66.3%. Participation rates have been increasing largely due to the growing number of women entering the labour force. However, mining is still a male-dominated industry. Since 1980, women have comprised between 6.0-6.5% of total employees, but the percentage of women who are production workers has fallen throughout the decade from 2.6% in 1981 to 1.7% in 1985.

The skill mix required in mining is changing rapidly with the introduction of new technology. Particularly in underground operations, high-skill and multi-skill occupations are now prevalent. At the same time, enrolment at mining technology schools is at a critical low level. With the growth of gold mining employment, skill shortages are beginning to emerge, particularly in Ontario and Quebec.

Mine closures are of particular concern. The impact of the closures can be especially acute since they often provide the main source of employment in remote single industry towns. Indefinite closures in 1987 include (1) Noranda Inc.'s copper mine at Murdochville resulting in 400 layoffs, (2) Pine Point Mines Limited's lead/zinc mine at Pine Point affecting 255 workers, (3) Domtar Inc.'s gypsum mine at Flat Bay, Newfoundland where 82 were laid off, and (4) Lac Minerals Ltd.'s Lake Shore mine near Kirkland Lake which affected 44 workers. Major workforce reductions, accomplished through either layoffs or early retirements, took place at the Iron Ore Company of Canada (IOC), INCO Limited, the Potash Corporation of Saskatchewan (PCS), and BHP-Utah Mines Ltd.

Through the Canada Employment and Immigration Commission (CEIC), the Government of Canada makes available a range of labour market programs of benefit to mining industry employees. Employers are invited to sign Industrial Adjustment Service agreements with CEIC under which layoffs or closures can be jointly managed to the benefit of displaced workers. In addition, some 30 mining dependent areas have been selected under the Community Futures program. Under this program, several forms of assistance can be made available including funding for local economic development planning, retraining, mobility assistance, financial assistance to small business, and a self-employment initiative. There are also other national programs under the Canadian Jobs Strategy, and application was made in late 1987 to have mining occupations covered under the Skill Shortages program.

INDUSTRIAL RELATIONS

By historical standards, the number of work stoppages in mining has been low in recent years. However, the year 1986 witnessed a small increase over 1985 in the number of work stoppages in the industry. While aggregate data for 1987 is not yet available, there appears to have been a further increase in the number of work stoppages.

In 1986, there were 14 work stoppages in mining; 7 in metals, 3 in nonmetals, and 4 in mineral fuels. There were 8796 workers involved and 351 870 person-days were lost. (Of the four stoppages in the mineral fuels sector, three were in coal mining involving 1977 workers and 110 870 person-days in down-time). This record is worse than in any year since 1981, but is much better than the late 1970s when in three separate years, 1.7, 1.6 and 1.2 million person-days were lost.

Aggregate dispute data is not yet available for 1987, but the year saw a series of labour disputes in the sector. Major work stoppages involving locals of the United Steelworkers of America took place at the Iron Ore Company of Canada (1 month) and Wabush Mines in Labrador (2 months), Northgate Mines Inc. at Chibougamau (1 month), Denison Mines Limited and Rio Algom Limited uranium operations at Elliot Lake (19 days), Dickenson Mines Limited at Balmertown, Ontario (17 days), and Cominco Ltd. operations at Trail and Kimberley (nearly 4 months). A twenty-day dispute between Minnova Inc. at Chapais and the Federation of Metal Trades occurred in June.

Effective wage increases in mining collective agreements averaged 1.5% in 1986, down from 4.0% in 1985. For the first two quarters of 1987, effective wage increases rose to an average of 2.6%. These increases appear low in comparison to the average for all industries which was 3.4% in 1986 and 3.8% for the first half of 1987. It should be noted that this data excludes non-wage benefits, which can range up to 40% of the value of total compensation.

A preliminary analysis of 1987 collective agreements can reveal trends in mining industry compensation packages. Wage freezes were still a common feature of collective agreements, but these tended to be accompanied by COLA clauses which effectively increased wages by 2.5-3.5%. However, wage increases were averaging less than the rate of inflation in virtually all cases. Enriched pension and/or early retirement provisions also appeared in most agreements, and in a small number of cases gain-sharing plans were negotiated. Agreements tended to be three years in duration, and shorter contract lengths were a notable exception.

SAFETY AND HEALTH

Legislative responsibility for mining safety and health rests largely with the provinces. As a result, national statistics in this area are poor. The Department of Energy, Mines and Resources is currently working with the provinces to develop a national mines accident data base.

The best current source of national injury statistics is the Statistics Canada series entitled "Work Injuries". It reports that there were 4342 time-loss injuries in metal mines in 1982, 3985 in 1983, 4097 in 1984, and 3996 in 1985. In nonmetal mines, there were 1261 time-loss injuries in 1982, 1129 in 1983, 1179 in 1984, and 1170 in 1985. Due to methodological problems, frequency rates are not reported.

Fatality data are more complete and published statistics are available for 1986. There were 79 fatalities in mining (including quarries and oil wells) in that year, down from 131 in 1985. These data include fatalities from occupational illnesses and deaths resulting from injuries which occurred in earlier years. An EMR survey of Chief Inspectors of Mines taken in mid-1987 focussed on fatalities directly due to mining accidents. It revealed that there were 25 fatalities as a result of mining accidents in 1986 and 24 during the period January to August 1987. For the period 1981-86, the total number of fatalities has ranged from 25 to 32.

Fatality frequency rates have continued their downward trend and the rate for 1986 was 0.54 per thousand workers. This rate is much higher than construction and manufacturing, but substantially better than fishing and forestry. Slightly more than half of the deaths in 1986 are attributable to occupational injuries, with the remainder being the result of occupational illnesses. A similar pattern was seen in 1984 and 1985.

Special concern arose as a result of the 17 fatalities in Ontario mines in 1987. There were nine fatalities in that province in 1986 and five in 1985. At the federal/provincial Mines Ministers' Conference in August 1987, Ministers asked Chief Inspectors of mines to examine recent fatalities nationally to assess causes and possible preventative measures. (This is in addition to the detailed accident investigations that are routinely conducted in each province following a mine accident). Chief Inspectors are expected to report their findings to the 1988 Mines Ministers' Conference.

LEGISLATIVE HIGHLIGHTS

Each year, federal and provincial governments enact a wide range of labour legislation that may have an impact on the mining industry. This chapter does not attempt to review all such legisation, but rather it outlines the relevant federal legislative developments in 1987 with very brief reference to selected provincial actions.

Workplace Hazardous Materials Information System (WHMIS)

Enabling legislation for WHMIS at the federal level received Royal Assent on June 30, 1987. When fully implemented in each jurisdiction, WHMIS will provide a national information standard for the protection of workers exposed to hazardous materials. WHMIS is the result of a four-year cooperative effort between industry, labour, and all levels of government which, according to the federal Minister of Labour, is "one of the most important workplace health and safety developments of the last decade".

Key provisions of WHMIS include (a) establishment of criteria for identifying hazardous materials, (b) a requirement that suppliers and importers ensure that hazardous materials are labelled, (c) a requirement that suppliers and importers provide up-to-date information on the hazards of products designated under WHMIS, and (d) protection of proprietary information.

The proposed federal regulations for WHMIS have been Gazetted and will take effect October 31, 1988. Provincial governments are also proceeding with the necessary legislative amendments to implement the federal regulations.

Pay and Employment Equity

Canada's Employment Equity Act was proclaimed in August 1986, requiring Crown corporations and federally-regulated employers with 100 or more employees to submit annual reports which show the representation of women, aboriginal peoples, disabled persons and visible minorities in specific salary ranges, occupational groups, hiring, promotions and terminations. The first analysis of these reports will take place after June 1, 1988. The Federal Contractors' Program makes a commitment to employment equity a condition of any bid over $200 000 submitted by a firm with 100 or more employees to supply the federal government with goods or services. The majority of mines, however, are subject to provincial human rights and labour standards legislation. Rather than introducing mandatory programs, these laws rely on voluntary programs and on individual complaints against specific discriminatory practices of individual employers.

Until recently, only the Canadian Human Rights Act, the Canada Labour Code and the Quebec Charter of Rights and Freedoms provided for equal pay for work of equal value, as agreed to in 1951 International Labour Organization Conventions. Although all provinces require employers within their jurisdictions to pay women and men equally for performing the same job, some provinces and territories have begun to address the issue of parity for women who have different jobs than men. Recent changes include complaint-based provisions for equal pay for work of equal value, pro-active pay equity programs for public sector employers, and Ontario's Pay Equity Act, passed in 1987, the only pro-active legislation in Canada that provides for the comparison of dissimilar jobs to determine equal value in both public and private sectors.

Severance Pay and Unemployment Insurance

The treatment of severance pay under the UI Act continued to attract attention in 1987. Since 1985, severance payments have been treated as earnings for UI purposes. In 1987, a loophole was closed which permitted employees to receive both severance pay and unemployment insurance in some cases. This provision has been subject to a transition period to allow for the amendment of collective agreements and company policies. The transition ends on March 26, 1988.

Pension Legislation Amendments

Pension legislation is a complex field and the features of the legislation vary widely among the jurisdictions. Virtually all mining pension plans fall under provincial jurisdiction, except those pertaining to mines in the two territories. Following an extensive pension reform process, the "Pension Benefits Acts" of Ontario, New Brunswick, and Nova Scotia were each extensively amended in 1987. Corresponding amendments to the federal "Pension Benefits Standards Act" took effect January 1, 1987. In an industry with high worker mobility, these pension reforms should help mining workers to protect their pension entitlements.

The amendments in the three provinces are generally similar. Major features include reduced periods for vesting and locking-in, improved portability, improved access to pensions for part-time workers, mandatory 50% employer funding (except New Brunswick), stricter controls on withdrawals of plan surpluses, and new provisions on spousal survivor benefits. Also, the Ontario and Nova Scotia Acts provide for inflation protection by way of indexing, but the specifics of this are still under review. The amendments also provide for increased disclosure of plan information by employers to plan members.

Tax Benefits for Northern and Isolated Posts

In December 1987, the Minister of Finance released guidelines for implementation of the February 1986 Budget proposals concerning taxation of housing and travel for residents of northern and isolated posts. The preliminary list of eligible communities included some 34 mining-dependent areas. The Minister of Finance also announced creation of a Commission of Enquiry into the appropriateness of the current criteria for determining isolated areas.

Under this tax system, which was in effect for the 1987 taxation year, residents of eligible communities may claim a housing deduction equal to 20% of net income to a maximum of $225 per month (or $450 per month for those who maintain their own home or apartment). Some exceptions apply depending on circumstances. Employees may also deduct from income the value of up to two employer-provided vacation trips to the nearest non-isolated designated city, as well as all employer-provided medical travel.

Hudson Bay Mining and Smelting Act

Effective in late 1987, legislative responsibility for safety and health at the Hudson Bay Mining and Smelting Co., Limited (HBM&S) operations at Flin Flon was transferred from the Government of Canada to the Government of Manitoba. Previously, HBM&S operations fell within federal jurisdiction because the location of the mine traversed provincial borders.

At the provincial level, other changes to labour legislation of particular note include (1) revisions to Ontario's mine safety regulations, (2) amendments to Ontario's "Employment Standards Act" to lengthen notice periods and extend severance pay requirements, (3) broad-based changes in the B.C. "Labour Code", (4) creation of a new Labour Relations Board in Quebec, and (5) the introduction of proposed changes to the Alberta "Labour Code".

OUTLOOK

Mining employment levels are affected by cyclical fluctuations in commodity markets as well as structural changes in mining methods, notably due to technological change. Since 1982, the Canadian mining industry has dramatically improved productivity, partly through reductions in labour costs. With the advent of bulk mining methods, and increasing international competition in commodity markets where Canadian companies are active, downward pressures on labour costs and employment can be expected to continue. This long-term phenomenon should be balanced to some extent in 1988 by strengthening commodity prices. In particular, gold mining employment should continue its upward trend. Concerns about skill shortages emerged in 1987, and a tightening of the overall mining labour market can be expected in 1988.

The growth in labour compensation in Canada across all industries is expected to remain below the rate of inflation in 1988. Based on 1987 collective agreement settlements, many of which will extend for three years, the same should hold true in mining. Major mining collective agreements (i.e. covering more than 500 employees) expiring in 1988 include LAB Chrysotile Inc., INCO Limited operations at Sudbury, Falconbridge Limited, Placer Dome Inc., Pamour Inc., The Algoma Steel Corporation, Limited, Westar Mining Ltd., and the Cape Breton Development Corporation (CBDC).

At time of writing, two major closures have been announced for 1988. The Bell asbestos mine at Thetford Mines is scheduled to close in March 1988 affecting about 450 workers. Around the same time, Pine Point Mines Limited's mill at Pine Point is expected to close resulting in some 130 layoffs.

TABLE 1. STRIKES AND LOCKOUTS IN CANADIAN MINING[1], 1964-86

Year	Strikes and Lockouts	Duration in Person-days
1964	12	69 640
1965	25	58 460
1966	36	450 430
1967	24	32 050
1968	21	100 800
1969	27	2 087 490
1970	15	53 680
1971	19	193 490
1972	32	334 680
1973	33	220 570
1974	61	515 250
1975	46	1 179 380
1976	49	579 430
1977	28	91 050
1978	39	1 699 460
1979	40	1 586 360
1980	33	418 270
1981	42	580 720
1982	8	257 140
1983	12	178 390
1984	9	37 120
1985	12	91 590
1986P	14	351 870

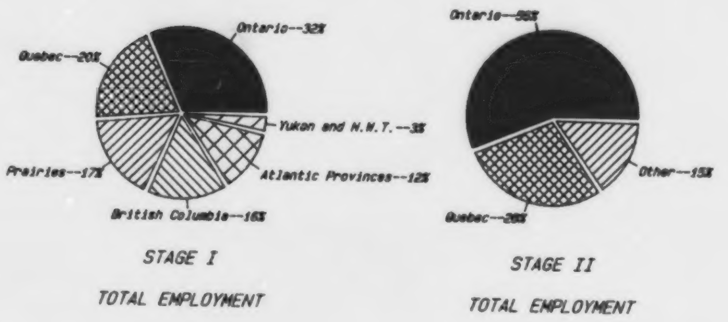
Source: "Canadian Minerals Yearbook", various issues.

[1] Includes metals, nonmetals, mineral fuels, and quarries.

P Preliminary.

FIGURE 1

CANADIAN MINING INDUSTRY AVERAGE EMPLOYMENT BY REGION – 1985



STAGE I

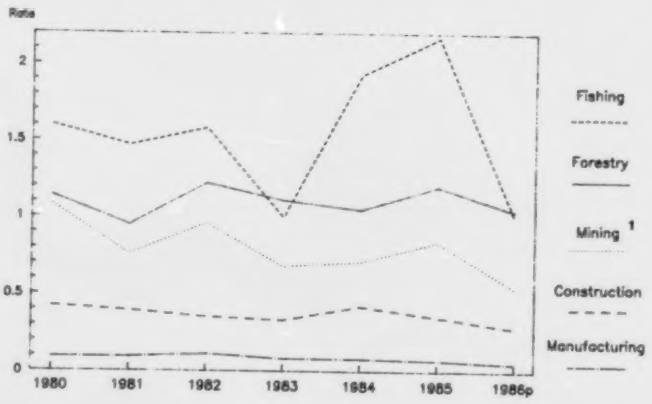
TOTAL EMPLOYMENT

STAGE II

TOTAL EMPLOYMENT

FIGURE 2

FATALITIES PER THOUSAND WORKERS, BY INDUSTRY: 1980–86



Note: Includes fatalities resulting from occupational chest illnesses.

1 Mining includes quarries and oil wells.

p Preliminary

Summary of Canadian Ore Reserves

(Data available in 1987)

J. ZWARTENDYK

Any assessment of future supply of a given mineral commodity from Canadian mines requires information on current working inventories, i.e., on the amounts of ore known to be present in operating mines and on additional known tonnages in deposits that are close to being profitably mineable. The tonnages that - in 1987 - were fairly well delineated and judged to be mineable are reported below as "reserves" (Figure 1). The limits of what is included in reserves are further specified in each case.

	1987
(A) Copper	13 331 000 t
Nickel	6 704 000 t
Lead	7 167 000 t
Zinc	22 423 000 t
Molybdenum	346 000 t
Silver	26 694 t
Gold	1 496 358 kg

The quantities of the metals listed above are contained in ore recoverable from current mines (including those "temporarily" closed) and from deposits that had been committed for production up to January 1, 1987.

These quantities represent proven and probable tonnages; any additional "possible" tonnages are not included.

(B) Iron 1 400 Mt

This is the approximate quantity of iron contained in known crude ore in producing mines. Ore in undeveloped deposits is not included.

(C) Asbestos 32.6 Mt

This represents the fibre content (on average, about 6%) of 544 Mt of mineable ore reserves in producing mines.

(D) Potash 14 000 Mt (K_2O equivalent), corresponding to 23 000 Mt KCl product (standard fertilizer - exported product)

This amount would be recoverable by conventional mining (to a depth of about 1 100 m) from known potash deposits. At least an additional 42 000 Mt (K_2O equivalent) would be recoverable from known deposits by solution mining at depths beyond 1 100 m; this would represent 69 000 Mt of KCl product.

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(E) Uranium

	"Reasonably Assured"	
	Proven (Measured)	Probable (Indicated)
	(tU)	
Recoverable from mineable ore, at uranium prices of:		
C$100/kg U or less:	46 000	107 000
$100 to $150/kg U:	1 000	95 000

The tonnages refer to uranium recoverable from mineable ore[1]. Unless otherwise specified, uranium "reserves" in Canada refer to the tonnages mineable at uranium prices in the low range only.

(F) Coal

- **Bituminous** 3 471 Mt (of which 1 918 Mt could be used for metallurgical purposes)
- **Subbituminous** 871 Mt
- **Lignitic** 2 236 Mt

These represent tonnages that could be profitably recovered as raw coal, given current technology and economics, from measured (proven) and indicated (probable) coal in deposits that are legally open to mining. For the purpose of making these estimates, it was assumed that coal sales would cover the costs of any required infrastructure not already in place[2].

THE FLOW FROM RESOURCES TO RESERVES TO MINERAL SUPPLY

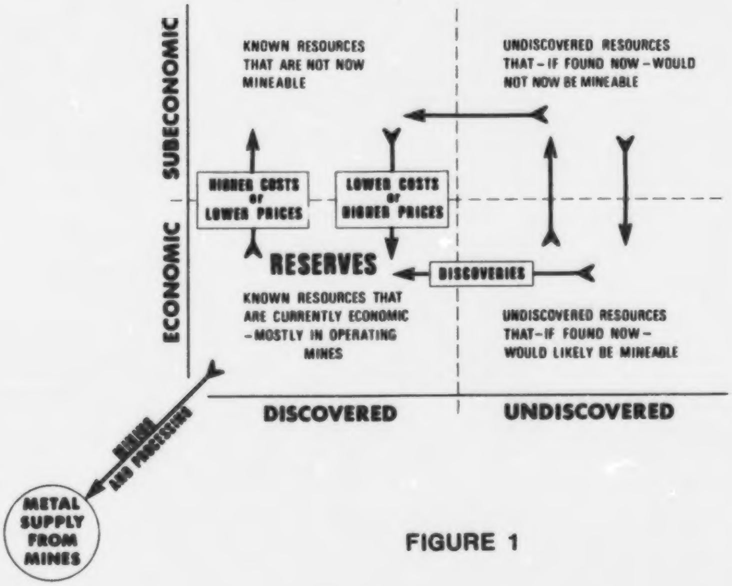
SUBECONOMIC
ECONOMIC
KNOWN RESOURCES THAT ARE NOT NOW MINEABLE
UNDISCOVERED RESOURCES THAT - IF FOUND NOW - WOULD NOT NOW BE MINEABLE
HIGHER COSTS or LOWER PRICES
LOWER COSTS or HIGHER PRICES
RESERVES
DISCOVERIES
KNOWN RESOURCES THAT ARE CURRENTLY ECONOMIC - MOSTLY IN OPERATING MINES
UNDISCOVERED RESOURCES THAT - IF FOUND NOW - WOULD LIKELY BE MINEABLE
DISCOVERED
UNDISCOVERED
MINING AND PROCESSING
METAL SUPPLY FROM MINES

FIGURE 1

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[1] September 1987, Energy, Mines and Resources Canada.

[2] CANMET Report 87-3E, "Coal Mining in Canada: 1986", Energy, Mines and Resources Canada, 1987.

Canadian Mine Reserves, Development and Promising Deposits

A. LEMIEUX

Table 1 illustrates the annually changing levels of Canadian reserves of seven major metals, in terms of the metal content of ore. These quantities were computed on the basis of information provided by mining companies. They pertain to ore tonnages that, as far as could be determined, were known at a level of assurance equivalent to "proven" and/or "probable". Tonnages reported as "possible" were not included. Table 2 shows a province-by-province breakdown for reserves as at January 1, 1987.

While the term "reserves" is widely used to refer to that part of mineral resources that, on a given date, is well delineated and considered economically mineable, the reserves in Table 1 and Table 2 are confined to those in producing mines and in deposits that have been committed for production. These reserves constitute the reliable core of information. For other deposits, where concrete steps have not been taken by companies to prepare them for mining, judgments by outsiders regarding economic mineability would not form a consistent basis for reporting reserves. The purpose of the "reserves" restrictions used here is to avoid such subjective judgments.

The quantities of reserves reported cannot, by themselves, give any indication of whether or not Canada might be running out of economically mineable minerals. Future production will draw not only on the 1987 reserves but also on additional reserves yet to be developed -- from discoveries, from extensions to known orebodies and from known but currently marginal or uneconomic material. EMR's annual mineral bulletin[1] on Canadian mines deals with Canadian capability for metal production both from operating mines and from known deposits for which future production can be considered likely.

Total national reserves of the seven nonferrous metals saw their last concerted rise in the 1979-81 period. Gold reserves have kept on rising, but reserves of the other metals have steadily declined since 1981-82. Compared with 1981, reserves in 1987 were down 21% for copper, 19% for nickel, 24% for zinc, 29% for lead, 37% for molybdenum, and 21% for silver. Gold reserves were up 94% since 1981. During 1986 alone, the downward trend continued for all these metals except gold, for which the reserves kept rising.

Mine by mine and province by province, there continued to be considerable departures from national trends. Reserves in most mines change slightly from year to year, but on balance these changes cancel out in national totals. It is the relatively few mines with large changes in reserves that affect the overall direction of national trends.

Gold. New mining operations and commitments to production that raised total Canadian gold reserves during 1986 were: the Hope Brook open-pit and underground mines in Newfoundland (Hope Brook Gold Inc.); the Dumagami mine (Dumagami Mines Limited) and the Isle Dieu Mattagami mine (Noranda Inc.) in Quebec; the Holt-McDermott mine (American Barrick Resources Corporation), the Bell Creek mine (Canamax Resources Inc. and Consolidated CSA Minerals Inc. - now Pamorex Minerals Inc.), the Mirado mine (Golden Shield Resources Ltd.), the Winston Lake mine (Corporation Falconbridge Copper - now Minnova Inc.), and the Norstar mine (Orofino Resources Limited), all in Ontario; the Snow Lake mine (stockpile) in Manitoba (Snow Lake Gold Corporation); the Nickel Plate mine in British Columbia (Mascot Gold Mines Limited); and the Tom mine in the Northwest Territories (Treminco Resources Ltd.).

Not all changes in reserves reflect actual ore delineation activities. Sizeable changes may also be brought about through shifts in reporting procedures. We accept both "proven" and "probable" reserves as

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[1] A. Lemieux, L.-S. Jen, G. Bouchard and D.A. Cranstone, "Canadian Mines: Perspective From 1987," Energy, Mines and Resources Canada, Ottawa.

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reasonably reliable, and many but not all companies report both, singly or combined. During 1986, the Dome Mines Group (now Placer Dome Inc.) announced that it would join the prevailing industry practice of including probable ore in its published reserves figures. It reported probable ore for the first time for the Campbell mine in Ontario and for the Sigma mine in Quebec. This change in reporting procedure more than doubled the published reserves of the Campbell mine from 1986 to 1987, resulting in the single largest net increase in gold reserves of any mine in Canada during 1986, equivalent to about four fifths of the 10% rise in national gold reserves. Placer Dome is expected to begin reporting also the probable reserves for the Dome mine in Ontario, which will provide another apparent strong boost to total Canadian gold reserves.

This type of administrative change can work the other way as well. The largest single decrease in gold reserves took place at Lac Minerals Ltd.'s Page-Williams mine at Hemlo, Ontario, where some ore formerly classified as proven-probable was reassigned to the "possible" category (not counted here in Canadian totals). This change, also, was made to conform to current industry practice for reporting reserves. If it had not been for that reclassification, Canadian reserves of gold would have increased about 16% from 1986 to 1987.

Copper. Operating mines in Ontario delineated most of the gross additions to the national total of copper reserves. In contrast, new mines -- Winston Lake and Isle Dieu Mattagami -- accounted for a very small part of the gross addition.

On balance, however, reserves declined 7% during 1986 because total gross additions to reserves did not fully replace ore mined and, more importantly, because some companies reassessed their ore reserves downward.

Industry reassessment of base-metal reserves in view of altered economic considerations has been going on for several years, generally resulting in lower reserves. On the other hand, during 1986, Placer Dome began to recover copper at its Gibraltar operations in British Columbia using a bioleaching process, from what had until recently been regarded as mine waste.

Nickel. Nickel reserves, too, were apparently reappraised downward, to a degree almost equivalent to mine production in 1986. Although down 5% from 1986 to 1987, reserves of nickel are still much larger relative to production levels than are the reserves of the other base metals.

Molybdenum. Molybdenum reserves decreased by 5% from 1986 to 1987. Gross additions to reserves were inadequate to make up for both mine production and downward reassessment of reserves. The largest write-down occurred at Placer Dome's Gibraltar mine where reserves were revised downwards, in part because of new geological information. Placer Dome's Endako mine, also in British Columbia, reported an ore reserves tonnage comparable to last year's, but with a slightly higher molybdenum grade, which made it the only mine with a net addition to molybdenum reserves from 1986 to 1987.

Silver. Reserves of silver were down by 7%, an amount roughly equivalent to 1986 mine production. Gross additions to reserves, partly in three new mines, were significantly smaller than the sum of 1986 mine production and write-downs of reserves at several mines. Large write-downs of reserves occurred particularly at the Gibraltar mine, where a new mining plan was put in place, and at Cominco Ltd.'s Sullivan mine. A reassessment in the positive direction was evident at Placer Dome's Equity mine, where material with a grade lower than that previously mined was added to reserves during 1986.

Zinc. Zinc reserves were down 6% from 1986 to 1987. Half a dozen mines had decreases in reserves exceeding their 1986 zinc production. The largest reported write-downs of reserves took place at Cominco's Pine Point mine in the Northwest Territories (8 Mt of ore) and at its Sullivan mine in British Columbia. The Winston Lake and Isle Dieu Mattagami deposits, both committed for production during 1986, provided additions to reserves.

Lead. As in the case of zinc, write-downs of reserves at the Pine Point and Sullivan mines were significant factors contributing to the 11% drop in lead reserves from 1986 to 1987. No mines reported significant additions to lead reserves during 1986.

Outlook. Reserves of base metals are likely to decline further in the coming years. Until the long-term market outlook improves markedly, incentives for vigorous exploration and ore development remain weak for base metals in comparison with gold.

Gold reserves are expected to be significantly higher in 1988, because of 1) commitments made during 1987 to develop several new conventional gold operations; 2) upward revisions of reserves through changes in reporting procedures, such as the expected first-time inclusion of "probable" ore at the Dome mine in Ontario; and 3) reprocessing of large tonnages of gold-bearing material left from past mining operations. Reprocessing projects have been announced by ERG Resources Inc. and Pamour Inc. at Timmins; by Lac Minerals Ltd. and by Eastmaque Gold Mines Ltd., both at Kirkland Lake; and by Giant Yellowknife Mines Limited, in the Northwest Territories.

The metal content of such gold-bearing material slated for reprocessing will qualify as "reserves", even if not of the conventional kind. It should, however, be noted that the gold recovery rate from such low-grade material will be very much lower than recoveries from higher grade conventional gold ores. As well, while some of these non-conventional gold operations will be sizeable in their own right and may together gain growing importance in the future, their contribution to Canada's total gold metal production in the next few years will still be minor.

DEVELOPMENT

Expenditures and New Commitments. During 1986, a total of some $920 million (a preliminary Statistics Canada estimate) was spent on mine development. The level of development expenditures has generally been on the rise (in constant dollars) since the late 1960s. Development expenditures in 1986 were roughly equal to the previous peak reached in 1984.

Figure 1(a) illustrates development expenditures since 1968. Development expenditures have been consistently higher than the more widely publicized expenditures on exploration. The ratio of exploration to development expenditures has varied generally within the range of 0.5-0.8 (Fig.1(b)).

New commitments announced during 1987 to develop, during the next few years, additional capability for ore and concentrate production in Canada amounted to more than $750 million; 70% of this was budgeted for precious-metal development, almost all gold. This was a significant increase from the less than $550 million announced during 1986, but considerably less than in 1983-84, a two-year period when new commitments amounted to nearly $2 billion because of several large projects, the likes of which were not launched during 1987 and are not expected to be during 1988. At least 37 new deposits were committed for production. This is an unusually large number, reflecting the results of record high exploration activity. At least 33 are gold deposits.

Promising Deposits. The number of additional deposits that we have judged on the basis of essentially the same criteria (tonnage, grade, cumulative exploration and development effort, and infrastructure), to be promising for production in the foreseeable future (Table 3) has grown each year for the past decade. Since 1977, that number has doubled to 145. The balance has swung toward gold: in 1977, only one promising deposit out of ten was a gold deposit; in 1987, eight out of ten are.

Outlook. A number of further production decisions are expected shortly, primarily on gold deposits, which will raise Canadian gold reserves even higher. Ongoing exploration and development work is expected to lead to the recognition during 1988 that an additional sizeable number of gold deposits may be developed into producing mines.

This bright outlook for new gold mines tends to obscure the deterioration in the outlook for new base-metal mines. The few promising base-metal deposits currently recognized will not be sufficient to take over from those current mines that have less than a decade of productive life left (see also chapter "Canadian Mineral Exploration"). Promising base-metal deposits are much rarer today than they used to be, partly because they have to be richer now to qualify as promising, given the current expectation of lower average prices than those that prevailed in the 1960s and 1970s.

TABLE 1

CANADIAN RESERVES, 1977-87

Quantities of Metals Contained in Proven and Probable Mineable Ore[1]
In Operating Mines and Deposits Committed for Production as at January 1st

Metal	Units[2]	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987[4]
Copper	000 t	16 634	16 471	15 840	16 405	16 831	15 815	17 022	16 163	15 788	14 384	13 331
Nickel	000 t	7 326	7 389	7 070	7 245	8 304	8 013	7 581	7 339	7 222	7 047	6 704
Lead	000 t	9 028	8 934	8 911	9 557	10 119	10 244	9 029	9 048	8 887	8 012	7 167
Zinc	000 t	27 407	26 908	26 452	28 635	29 436	29 505	26 077	26 371	26 218	23 747	22 423
Molybdenum	000 t	377	384	462	554	550	514	494	446	392	363	346
Silver	t	30 490	29 085	29 398	31 564	33 614	32 154	31 381	31 359	31 298	28 795	26 694
Gold[3]	kg	396 012	366 421	409 582	540 493	769 889	842 215	837 707	1 166 677	1 204 842	1 358 050	1 496 358

[1] No allowance is made for losses in milling, smelting and refining. [2] One tonne = 1.1023113 short tons. One kilogram = 32.150746 troy ounces. [3] Excludes metal in placer deposits. [4] Includes metal in mines where production has been suspended indefinitely.

TABLE 2

CANADIAN RESERVES BY PROVINCE

Quantities of Metals Contained in Proven and Probable Mineable Ore[1]
In Operating Mines and Deposits Committed for Production as at January 1, 1987[2]

Metal	Units[3]	Nfld.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	B.C.	Y.T.	N.W.T.	Canada[5]
Copper	000 t	-	62	330	623	6 260	492	5	5 560	-	-	13 331
Nickel	000 t	-	-	-	-	4 908	1 796	-	-	-	-	6 704
Lead	000 t	-	-	3 648	-	133	25	0	1 256	1 275	831	7 167
Zinc	000 t	58	104	8 964	987	3 972	641	1	2 516	1 958	3 222	22 423
Molybdenum	000 t	-	-	-	1	13	-	-	333	-	-	346
Silver	t	-	-	9 759	1 506	6 893	721	2	5 838	1 849	126	26 694
Gold[4]	kg	42 971	-	72 251	229 387	881 898	40 478	2 283	162 528	7 065	57 496	1 496 358

[1] No allowance is made for losses in milling, smelting and refining. [2] Includes metal in mines where production has been suspended indefinitely. [3] One tonne = 1.1023113 short tons. One kilogram = 32.150746 troy ounces. [4] Excludes metal in placer deposits. [5] May not balance due to rounding at the provincial level.
- Nil.

TABLE 3

TONNAGES AND GRADES OF ADDITIONAL DEPOSITS CONSIDERED IN LATE 1987 MOST PROMISING FOR FUTURE PRODUCTION

1. DEPOSITS: Individual deposits have been selected primarily on the basis of information contained in current public reports with respect to (a) state of exploration and development, (b) tonnage and grade, (c) available infrastructure, and (d) mining method and other factors affecting viability. This list includes few deposits for which no recent exploration and development activities have been publicly reported.
2. TONNAGE and GRADE: As reported by companies or, where necessary, from the secondary source that appeared to be the best informed. Imperial units reported were converted to metric units and rounded.
3. Where two or more companies are identified with a deposit, the first is usually the operator.

COMPANY AND DEPOSIT	TONNAGE	GRADE						
		Cu	Ni	Pb	Zn	Mo	Ag	Au
	tonnes[1]	%	%	%	%	%	g/t	g/t
NEWFOUNDLAND								
Dolphin Explorations Ltd. Mascot Gold Mines Limited Cape Ray	630 800	-	-	-	-	-	14.98	8.02
NOVA SCOTIA								
Acadia Mineral Ventures Limited Mooseland	585 000	-	-	-	-	-	-	8.2
Coxheath Gold Holdings Limited Tanzier	454 000	-	-	-	-	-	-	10.5
Greenstrike Gold Corp. Pan East Resources Inc. Fifteen Mile Stream mine	550 000	-	-	-	-	-	-	8.
INCO Limited Northumberland Mines Limited Cochrane Hill	900 000	-	-	-	-	-	-	11.0
Onitap Resources Inc. Petromet Resources Limited Greenstrike Gold Corp. Goldboro	454 000	-	-	-	-	-	-	5.1
Seabright Resources Inc. Oldham & Montague - tailings	339 000	-	-	-	-	-	-	1.66
NEW BRUNSWICK								
Lacana Mining Corporation M.E.X. Explorations Ltd. Elmtree Brook	408 000	-	-	-	-	-	-	4.8

Table 3. (cont'd)

COMPANY AND DEPOSIT	TONNAGE	GRADE Cu	Ni	Pb	Zn	Mo	Ag	Au
	tonnes[1]	%	%	%	%	%	g/t	g/t
Lincoln Resources Inc. Placer Dome Inc. Third Portage Lake (Restigouche)	2 721 600	0.34	-	4.5	6.0	-	86.0	-
Noranda Exploration Company, Limited Cancord Resources Inc. Conwest Exploration Company Limited Half-Mile Lake	12 338 000	0.19	-	2.52	7.50	-	31.	-
QUEBEC								
Amberock Mining Resources Inc. Louvem Mines Inc. Camsul Inc. Courvan	367 400	-	-	-	-	-	-	4.66
Abcourt Mines Inc. Aunore Resources Inc. Nova Beaucage Mines Limited Elder	2 809 800	-	-	-	-	-	-	7.51
Amberquest Resources Ltd. New Goldcore Ventures Ltd. Cambior inc. Rouyn-Merger	466 300	-	-	-	-	-	-	6.1
Augmitto Explorations Limited Durbar (Beauchastel)	1 320 000	-	-	-	-	-	-	5.5
Aumine Exploration Camsul Inc. Goldstack Resources Ltd. Dubuisson (Malartic Goldfields)	1 050 800	-	-	-	-	-	-	5.99
Aur Resources Inc.								
First Canadian - Kierens	635 000	-	-	-	-	-	-	6.9
Orenada - Zone 4 (Bourlamaque)	671 000	-	-	-	-	-	-	5.5
Belmoral Mines Ltd. Wrightbar Mines Ltd. Wrightbar (Bourlamaque)	307 100	-	-	-	-	-	-	6.72
Cambior inc. New Pascalis Mines Limited New Pascalis	720 000	-	-	-	-	-	-	3.9

Campbell Resources Inc.								
Devlin mine (Obalski)	1 134 000	2.25	-	-	-	-	-	-
Main mine (Obalski) - pillar	2 015 000	0.85	-	-	-	-	-	0.10
Camsul Inc.								
Rouanda Mines Inc.								
Cambior inc.								
Eldrich-Flavel (Duprat)	1 658 000	-	-	-	-	-	-	5.58
Camsul Inc.								
Bachelor Lake Gold Mines Inc.								
Flordin (Desjardins)	527 769	-	-	-	-	-	-	5.0
Eastern Mines Ltd.								
Silver Sceptre Resources Ltd.								
Hosco-Heva (Joannes)								
- Hosco	1 221 200	-	-	-	-	-	-	4.00
- Heva	1 805 000	-	-	-	-	-	-	5.5
Exploration Essor Inc.								
Black Cliff Mines Limited								
Vinray	118 000	-	-	-	-	-	-	8.2
Exploration Monicor Inc.								
Monique (Louvicourt)	591 000	-	-	-	-	-	-	5.93
Goldex Mines Limited								
Probe Mines Limited								
Goldex (Dubuisson)	777 000	-	-	-	-	-	-	7.17
INCO Gold								
Golden Knight Resources Inc.								
Golden Pond Main	2 694 000	-	-	-	-	-	-	7.5
Golden Pond West	3 824 000	-	-	-	-	-	-	6.5
Louvem Mines Inc.								
Pascalis-Nord (Pascalis)	233 500	-	-	-	-	-	-	6.8
Malartic Hygrade Gold Mines (Canada) Ltd.								
Orion	204 230	-	-	-	-	-	-	8.47
McAdam Resources Inc.								
Tashota-Nipigon Mines Limited								
Quinteko Resources Ltd.								
McWatters	822 000	-	-	-	-	-	-	5.5
Minnova Inc.								
Syngold Exploration Inc.								
Delbridge Kerralda	729 000	-	-	-	-	-	-	8.6

Table 3. (cont'd)

COMPANY AND DEPOSIT	TONNAGE	GRADE						
		Cu	Ni	Pb	Zn	Mo	Ag	Au
	tonnes[1]	%	%	%	%	%	g/t	g/t
QUEBEC (cont'd)								
Noranda Inc. Cambior inc. Nova-Cogesco Resources Inc. Silidor (Ribago-Waite Beauchastel)	4 400 000	-	-	-	-	-	-	6.4
Noranda Inc. Nuinsco Resources Limited New Inasco (Hébécourt)	793 000	2.59	-	-	-	-	21.	-
Norbeau Mines Inc. Norbeau mine (McKenzie)	916 000	-	-	-	-	-	-	7.2
Northgate Mines Inc. Bateman Bay (McKenzie)	678 700	1.76	-	-	-	-	13.7	3.38
Nova-Cogesco Resources Inc. Aur Resources Inc. Nolartic (Vassan)	1 316 940	-	-	-	-	-	-	4.10
NSR Resources Inc. Rand Malartic Mines, Limited Nova-Cogesco Resources Inc. Rand Malartic	60 500	-	-	-	-	-	-	12.4
Perron Gold Mines Ltd. Noranda Exploration Company, Limited Nova-Cogesco Resources Inc. Sleeping Giant (Chaste)	1 726 020	-	-	-	-	-	-	9.46
Placer Dome Inc. MSV Resources Inc. Eastmain River	1 013 000	0.27	-	-	-	-	15.1	15.3
Placer Dome Inc. Western Quebec Mines Inc. Westdome	1 147 600	n.a.	-	-	-	-	-	4.11
Quebec Explorers Corporation Ltd. Nova-Cogesco Resources Inc. Dubuisson	237 000	-	-	-	-	-	-	7.23

Rouyn Mining Resources Inc.								
Lac Fortune	234 050	-	-	-	-	-	-	5.37
Rouyn Mining Resources Inc.								
Lac Minerals Ltd.								
Francoeur mine	2 000 000	-	-	-	-	-	-	6.70
Wasamac - pillar	740 550	-	-	-	-	-	-	3.39
- underground	858 370	-	-	-	-	-	-	5.11
Teck Corporation								
Golden Hope Resources Inc.								
Golden Group Explorations Inc.								
Estrades								
- East zone	602 145	0.99	-	-	7.51	-	68.6	1.0
- Main zone	889 683	0.62	-	1.04	9.03	-	163.5	6.2
- Middle zone	848 463	0.85	-	-	5.59	-	75.8	5.1
Western Quebec Mines Inc.								
Oracle Exploration Inc.								
Joubi	541 370	-	-	-	-	-	-	5.82
Yorbeau Resources Inc.								
Ellison - A zone	781 000	-	-	-	-	-	-	6.9
Yorbeau Resources Inc.								
Campbell Resources Inc.								
ERG Resources Inc.								
Astoria (Rouyn)	1 272 409	-	-	-	-	-	-	6.14
ONTARIO								
American Barrick Resources Corporation								
Lenora Explorations Ltd.								
Worvest	196 231	-	-	-	-	-	-	6.64
Camreco Inc.								
Goldlund	181 000	-	-	-	-	-	-	5.8
Windfall	275 673	-	-	-	-	-	-	5.8
Canamax Resources Inc.								
Bruneau Mining Corporation								
Clavos (German & Stock)	470 000	-	-	-	-	-	-	7.31
Canamax Resources Inc.								
Procan Exploration Company Limited								
Matheson East zone	522 900	-	-	-	-	-	-	7.4
Citadel Gold Mines Inc.								
Surluga-Pango	1 451 500	-	-	-	-	-	-	4.8
Consolidated Professor Mines Limited								
Duport	1 387 149	-	-	-	-	-	-	12.

Table 3. (cont'd)

COMPANY AND DEPOSIT	TONNAGE	GRADE Cu	 Ni	 Pb	 Zn	 Mo	 Ag	 Au
	tonnes[1]	%	%	%	%	%	g/t	g/t
ONTARIO (cont'd)								
Echo Bay Mines Ltd. Nuinsco Resources Limited Cameron Lake	1 400 000	-	-	-	-	-	-	5.5
Freegold Recovery Inc. Kirkland Lake - tailings	534 000	-	-	-	-	-	-	0.7
Freegold Recovery Inc. Placer Dome Inc. Balmerton - tailings	4 000 000	-	-	-	-	-	-	1.75
Getty Resources Limited Davidson Tisdale Mines Limited Tisdale	550 000	-	-	-	-	-	-	8.9
Golden Princess Mining Corporation Noranda Exploration Company, Limited Nickel Offsets	544 000	-	-	-	-	-	-	7.9
Goldpost Resources Inc. New Kelore Mines Limited Hislop West	362 800	-	-	-	-	-	-	5.8
Highland-Crow Resources Ltd. Pickle Crow - geological	6 651 084	-	-	-	-	-	-	7.9
INCO Gold Queenston Gold Mines Limited Anoki	544 000	-	-	-	-	-	-	4.97
Intex Mining Company Limited Frankfield Explorations Ltd. Tully	272 000	-	-	-	-	-	-	8.2
Jamie Frontier Resources Inc. Pipestone Bay	72 700	-	-	-	-	-	-	17.0
Kerr Addison Mines Limited Eldor Resources Limited Larder Lake	737 300	-	-	-	-	-	-	5.97
Lincoln Resources Inc. Noranda Exploration Company, Limited Band-Ore Gold Mines Limited Shebandowan	590 000	-	-	-	-	-	7.71	4.73

Massive Resources Ltd. Twin Gold Mines Ltd. Lingman Lake	1 333 780	-	-	-	-	-	-	8.9
McFinley Red Lake Mines Limited Phoenix Gold Mines Limited McFinley (Bateman)	237 700	-	-	-	-	-	-	9.3
Mono Gold Mines Inc. Bannockburn	337 612	-	-	-	-	-	-	13.5
Muscocho Explorations Ltd. Flanagan McAdam Resources Inc. Windarra Minerals Ltd. Mishibishu Lake (Magnacon)	635 000	-	-	-	-	-	-	7.2
Muscocho Explorations Ltd. McNellen Resources, Inc. Magino	1 747 823	-	-	-	-	-	-	8.61
Noranda Exploration Company, Limited Stan West Mining Corp. De Santis mine	269 946	-	-	-	-	-	-	5.3
Norben Gold Resources Inc. Pancontinental Mining (Canada) Ltd. Ateba Mines Inc. Northern Empire	136 000	-	-	-	-	-	-	2.
Novamin Resources Inc. Eldor Resources Limited Cadieux	904 800	-	-	0.87	9.61	-	-	-
Novamin Resources Inc. First General Mine Management & Gold Corp. Rundle South	157 000	-	-	-	-	-	-	8.8
Orofino Resources Limited Orofino mine	220 000	-	-	-	-	-	-	8.2
Placer Dome Inc. INCO Limited Esso Minerals Canada Lacana Mining Corporation Musselwhite (Snoppy Lake)	3 600 000^{e}	-	-	-	-	-	-	7.^{e}
Silverside Resources Inc. Proteus Resources Inc. Garrison	250 000	-	-	-	-	-	-	5.8

Table 3. (cont'd)

COMPANY AND DEPOSIT	TONNAGE	Cu	Ni	Pb	Zn	GRADE Mo	Ag	Au
	tonnes[1]	%	%	%	%	%	g/t	g/t
ONTARIO (cont'd)								
St. Andrew Goldfields Ltd. Esso Minerals Canada Taylor Township	989 000	-	-	-	-	-	-	4.32
Vedron Limited Belmoral Mines Ltd. Vedron-Romfield	907 000	-	-	-	-	-	-	7.
Zahavy Mines Limited Getty Resources Limited Favourable Lake	891 000	-	-	0.77	1.12	-	165.	8.9
MANITOBA								
Balcor Resources Corp. SherrGold Inc. Lasthope Lake	127 000	-	-	-	-	-	-	7.9
Bighorn Development Corporation Island Lake (Ministik mine)	151 000	-	-	-	-	-	-	13.
Hudson Bay Gold Inc. Manitoba Mineral Resources Ltd. Farley Lake - geological	1 430 000	-	-	-	-	-	-	6.34
Granges Exploration Ltd. Alberta Lake	363 000	-	-	-	-	-	-	7.5
Morgan Lake	272 000	-	-	-	15.	-	-	3.4
High River Resources Ltd. Nor-Acme Gold Mines, Limited Snow Lake - underground	764 100	-	-	-	-	-	-	5.5
San Antonio Resources Inc. Mandor Mining Corp. San Antonio	1 400 000	-	-	-	-	-	-	7.13
SherrGold Inc. Nisku	494 000	-	-	-	-	-	-	5.5
SherrGold Inc. Novamin Resources Inc. Dot Lake	1 000 000	-	-	-	-	-	-	3.8

Snow Lake Mines Ltd. Silver Hart Mines Ltd. Snow Lake - No. 3 and Birch zones	732 000	-	-	-	-	-	-	9.12
Trans America Industries Ltd. SherrGold Inc. Wasekwan Lake	910 000	-	-	-	-	-	-	3.1
Zenco Resources Inc. Snow Lake Mines Ltd. Squall Lake - near surface	680 000	-	-	-	-	-	-	3.
SASKATCHEWAN								
Golden Rule Resources Ltd. Goldsil Resources Ltd. Saskatchewan Mining Development Corporation (SMDC) Tower Lake - east	1 400 000	-	-	-	-	-	-	3.
Golden Rule Resources Ltd. Saskatchewan Mining Development Corporation (SMDC) Weedy Lake	785 000	-	-	-	-	-	-	4.5
Granges Exploration Ltd. *Saskatchewan Mining Development* Corporation (SMDC) Bigstone Lake	3 600 000	1.8	-	-	1.1	-	-	-
Lenora Explorations Ltd. New Athona	2 832 658	-	-	-	-	-	-	2.4
Lenora Explorations Ltd. Mary Ellen Resources Ltd. Box	9 000 000	-	-	-	-	-	-	1.7
Placer Dome Inc. Claude Resources Inc. Seabee (Laonil Lake)	1 978 080	-	-	-	-	-	-	6.5
Placer Dome Inc. Waddy Lake Resources Inc. Komis	1 200 000	-	-	-	-	-	-	4.18
Royex Gold Mining Corporation Mahogany Minerals Resources Inc. Jolu	835 000	-	-	-	-	-	-	21.
Saskatchewan Mining Development Corporation (SMDC) Claude Resources Inc. Jojay	281 000	-	-	-	-	-	-	8.9
Vista Mines Inc. Bootleg Lake	166 805	-	-	-	-	-	-	10.

Table 3. (cont'd)

COMPANY AND DEPOSIT	TONNAGE	GRADE Cu	Ni	Pb	Zn	Mo	Ag	Au
	tonnes[1]	%	%	%	%	%	g/t	g/t
BRITISH COLUMBIA								
Afton Operating Corporation Cominco Ltd. Imperial Metals Corporation Ajax	9 000 000	0.5[e]	-	-	-	-	n.a.	n.a.
Candorado Mines Ltd. Hedley - tailings	1 525 300	-	-	-	-	-	0.45[e]	1.41
City Resources (Canada) Limited Graham Island	25 000 000	-	-	-	-	-	-	2.1
Curragh Resources Corporation Cirque	21 700 000	-	-	2.7	9.0	-	57.0	-
Dolly Varden Minerals Inc. Dolly Varden, North Star, Torbrit and Wolf mines	1 272 695	-	-	-	-	-	347.	-
Energex Minerals Ltd. Toodoggone (AL) - open pit	238 000	-	-	-	-	-	-	8.6
Granges Exploration Ltd. Windflower Mining Ltd. Windflower	181 000	-	-	-	-	-	-	10.
Gunsteel Resources Incorporated Nugget	66 600	-	-	-	-	-	-	15.
Houston Metals Corporation New Nedina Explorations Limited Silver Queen	544 000	0.49	-	1.49	6.53	-	257.	3.70
Mascot Gold Mines Limited Bralorne Resources Limited E & B Explorations Ltd. Bralorne-Pioneer	941 239	-	-	-	-	-	-	9.3
Mascot Gold Mines Limited Golden North Resource Corporation Canty	685 000	-	-	-	-	-	-	3.67

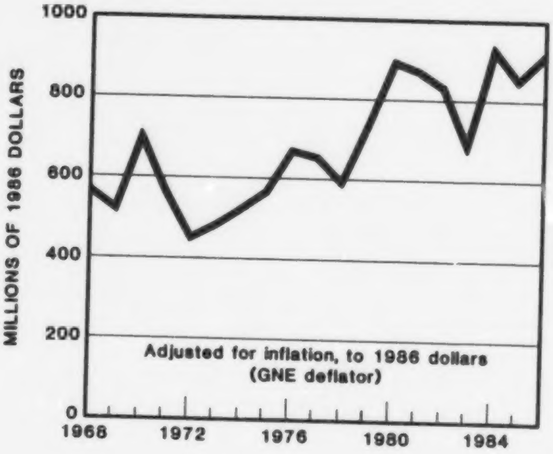
McAdam Resources Inc. Tashota-Nipigon Mines Limited Spud Valley (Zeballos)	389 666	-	-	-	-	-	-	8.6
Minnova Inc. Pacific Cassiar Limited Chu Chua	2 500 000	2.0	-	-	0.5	-	9.	0.5
Minnova Inc. Rea Gold Corporation Adams Lake	241 000	0.52	-	2.1	2.2	-	72.0	6.5
Samasotum	670 000	0.95	-	2.43	2.08	-	717.	1.4
Newhawk Gold Mines Ltd. Lacana Mining Corporation Granduc Mines Limited Sulphurets - all zones	1 437 112	-	-	-	-	-	783.7	11.5
New Privateer Mine Limited Privateer-Prident	447 000	-	-	-	-	-	-	13.
Northair Mines Ltd. BP Canada Inc. Rio Algom Limited Willa	550 000	1.04	-	-	-	-	9.6	7.5
Redfern Resources Ltd. Tulsequah Chief	708 000	1.3	-	1.6	8.0	-	99.	2.
Regional Resources Ltd. Canamax Resources Inc. Procan Exploration Company Limited Midway	1 185 000	-	-	7.0	9.6	-	410.	n.a.
Teck Corporation Pacific Cassiar Limited Porter-Idaho and Prosperity	826 500	-	-	2.0^e	3.0^e	-	669.0	-
Teeshin Resources Ltd. Canadian-United Minerals Inc. Dome Mountain	257 000	-	-	-	-	-	96.	14.9
Trader Resource Corp. Tel	293 870	-	-	-	-	-	n.a.	24.
Westmin Resources Limited Silbak Premier Mines Ltd. Silbak Premier - mineable	5 868 420	-	-	-	-	-	80.2	2.2
Westmin Resources Limited Tournigan Mining Explorations Ltd. Big Missouri - mineable	1 583 800	-	-	-	-	-	29.	3.60

Table 3. (cont'd)

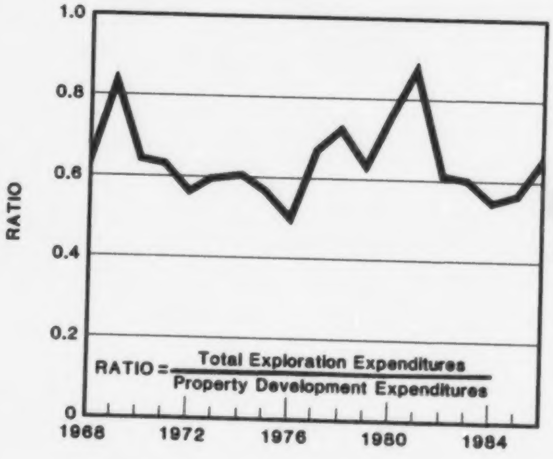
COMPANY AND DEPOSIT	TONNAGE	Cu	Ni	Pb	Zn	GRADE Mo	Ag	Au
	tonnes[1]	%	%	%	%	%	g/t	g/t
YUKON TERRITORY								
Aberain Corporation								
Cassiar Mining Corporation								
Jason	6 200 000	-	-	10.52	8.14	-	135.0	-
Canamax Resources Inc.								
Mt. Hundere	2 485 000	-	-	8.4	12.9	-	65.	-
Chevron Minerals Ltd.								
B.Y.G. Natural Resources Inc.								
Mt. Nansen - Brown McDade zone	700 000	-	-	-	-	-	69.	7.9
Curragh Resources Corporation								
DY	21 000 000	-	-	5.6	6.9	-	85.03	-
Grum	15 600 000[e]	-	-	3.1	5.0	-	47.0	-
Vangorda	6 100 000[e]	-	-	3.5	4.6	-	50.0	-
Omni Resources Inc.								
Skukum Creek	379 000	-	-	-	-	-	-	14.[e]
NORTHWEST TERRITORIES								
Echo Bay Mines Ltd.								
Comaplex Resources International Ltd.								
Kim	566 248	-	-	-	-	-	-	7.2
Falconbridge Limited								
Izok Lake	11 023 000	2.8	-	1.4	13.77	-	70.3	-
Giant Bay Resources Ltd.								
Gordon Lake	100 000	-	-	-	-	-	-	21.
Noranda Exploration Company, Limited								
Getty Resources Limited								
Tundra (Courageous Lake)	1 161 000	-	-	-	-	-	-	9.6
Orofino Resources Limited								
Canuc Resources Inc.								
Coronation Gulf	776 000	-	-	-	-	-	-	7.5
Neptune Resources Corp.								
Colomac (Indin Lake)	12 000 000	-	-	-	-	-	-	2.9

[1] One tonne = 1.1023113 short tons; 1 gram per tonne (g/t) = 0.02916668 troy ounces per short ton.
n.a. Not available; - Nil; [e] Author's estimate.

Figure 1



(a)
EXPENDITURES ON PROPERTY DEVELOPMENT



(b)
EXPLORATION VS DEVELOPMENT

SOURCES: Statistics Canada and Federal–Provincial Field Expenditure Survey.

Canadian Mineral Exploration

G. BOUCHARD AND D.A. CRANSTONE

ACTIVITY[1]

Exploration Expenditures: Total off- and on-property field exploration expenditures in Canada in 1986 reached $611 million. Related overhead expenditures (land acquisition costs, field administration costs and exploration-related head office expenses) add 25% or so to this total. In 1987, on- and off-property field exploration expenditures are estimated to have climbed beyond $850 million (Figure 1).

Flow-through Share Funding: Over the last several years, the financing of mineral exploration has been greatly facilitated by flow-through shares (by which income tax benefits "flow through" to the subscriber). Funds raised by flow-through shares covered about three-quarters of all field exploration expenditures (on- and off-property) in 1986, and probably more in 1987. In 1986, close to $450 million of exploration was financed by flow-through shares and, in 1987, the figure may well have been of the order of $700 million.

Claim Staking: Relative to 1985, the total area of claims staked in 1986 in Canada was up by 32% (Figure 1). In 1987, it was larger still. The largest increases in 1986 were in Quebec, Ontario and Manitoba.

Diamond-Drilling: The record high number of metres of diamond-drilling nationwide in 1985 was exceeded in 1986 by more than one-quarter (Figure 1). Indications are that, in 1987, the 1986 record was broken in turn, by a wide margin.

Since 1980, the federal Department of Energy, Mines and Resources has made efforts towards achieving greater inter-provincial consistency in the information gathered from industry on exploration activity. Coordination with provincial and territorial officials in the design of provincial surveys that allow nationwide comparisons and analyses has led to a much more reliable and detailed set of Canadian exploration data (see Figures 2 to 6).

Some observations on the results of the survey of 1986 activities are given below:

Exploration Expenditures by Province and Territory - 1986 (Table 1 and Figure 2)

- The most active areas remained Quebec and Ontario. In Quebec, 1986 field exploration expenditures were $242 million, a steep rise from the $135 million spent in 1985. In Ontario, expenditures were $137 million, almost 50% higher than in 1985. In 1987, exploration expenditures in both provinces continued to climb.
- In the Yukon, 1986 exploration expenditures (relative to 1985) were up 20%; in Saskatchewan and Newfoundland they remained at comparable levels; but in the Northwest Territories, British Columbia, Alberta, Manitoba and New Brunswick, expenditures were notably down.

Exploration Expenditures by Commodities Sought - 1986 (Figure 3)

- About three-quarters of Canadian exploration spending in 1986 (and almost certainly more in 1987) was directed at precious metals, chiefly gold, up from two-thirds in 1985.
- Field expenditures in 1986 were distributed by commodity target groups as follows:

Precious metals (primarily gold; some silver and platinum-group metals)	76%
Copper, zinc, lead and nickel	14%
Uranium	5%
Coal	2%
Others	3%

---

[1] Oil and gas are not covered by exploration statistics given here. In the case of new claims recorded, coal is excluded as well.

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- Relative to 1985, the amounts spent on exploration in 1986 were up (+) or down (-) as follows:

Precious metals	+49%
Copper, zinc, lead and nickel	-13%
Uranium	-18%
Coal	-55%

- In contrast to the strong rise in gold exploration, expenditures on base-metal exploration (on- and off-property) declined by 13%, from $99 million in 1985 to $86 million in 1986 -- with no signs of a rise in 1987 -- while total exploration expenditures rose from $491 million to $611 million.

Regional Exploration Expenditures by Commodities Sought - 1986 (Figure 4)

- Gold was the principal exploration target in 1986 in all provinces and territories except in Saskatchewan and Alberta; as in 1985, more money was spent in Saskatchewan on the search for uranium, and in Alberta for coal and uranium, than for all base and precious metals together. In Saskatchewan, exploration expenditures for gold in 1987 apparently surpassed those for uranium, for the first time since the mid-1940s, because of increased gold exploration in the La Ronge area.

- Expenditures in Alberta in 1986 were only 20% of those in 1985 because of a major decline in coal exploration.

- In Nova Scotia, at least five significant gold deposits were discovered between 1983 and 1986, most of them in old gold mining areas that had long been thought to be exhausted. This surprising success inspired a rise in 1986 exploration expenditures in the province to $17 million, more than twice the 1985 level, and all indications are that 1987 expenditures were three to four times as high as those of 1986.

Regional Exploration Expenditures by Types of Companies - 1986 (Figure 5)

- Junior companies were the dominant spenders in Quebec, the Yukon and Nova Scotia, where they spent more than all other types of companies combined. In British Columbia, the "Juniors" accounted for almost half of the 1986 exploration spending. Producing companies, together with their affiliates, were the largest spenders in all other provinces and the Northwest Territories.

- Foreign companies spent 94% of their Canadian exploration funds in Ontario, Saskatchewan, the Northwest Territories and Quebec.

Exploration Expenditures by Types of Companies and Commodities - 1986 (Figure 6)

- Of the total expenditures for precious metals exploration, junior companies contributed about 55% and producing companies and their affiliates about 40%.

- Of the money spent on Canadian exploration for base metals, producing companies and their affiliates provided about two-thirds and junior companies just under one-third.

- Of the Canadian exploration spending by foreign companies, about 50% was aimed at precious metals and 40% at uranium.

Types of companies engaged in exploration - 1985 and 1986 (Table 2)

- Exploration expenditures by oil companies were sharply down, from $48 million in 1985 to $9 million in 1986.

- Junior companies spent twice as much on exploration in 1986 as in 1985. Nonetheless, senior mining companies still spent 44% of the 1986 total. The "Others" category spent 48%, almost all of which was attributable to junior companies. Thus, the junior and senior mining companies spent roughly equal amounts on exploration in 1986.

EXPLORATION RESULTS

Figure 7 shows the numbers of annual discoveries, regardless of size, considered to be potential sources of metals. A discovery refers here to a mineral deposit sufficiently attractive to have warranted the expenditure necessary to establish its tonnage and grade. The date of discovery was normally taken to be the year when drilling led to the recognition that the deposit was of sufficient economic interest to justify the expenditures necessary to establish its tonnage and grade without significant delay.

Experience has shown that the number of generally recognized discoveries for a given year rises with the passage of time. For example, the 1985 discoveries compiled in late 1986 amounted to 30; by late 1987 this total had risen to 43. The number of 1984 discoveries recognized in late 1985 was 12, in late 1986 it had grown to 24, and by late 1987 it stood at 29. Given this experience, the current count of 35 discoveries for 1986 is likely to be comparably incomplete and the final number for 1986 may well exceed the all-time record (for the period 1845-1985) of 50 metallic mineral deposits discovered in Canada in the year 1981, which was, prior to 1986, the year of all-time high spending as well. Mineral discoveries continued at a high rate through 1987.

About four out of every five of the metallic mineral deposits discovered in 1986 were gold deposits, up from two out of three in 1985. These proportions are equivalent to those of total Canadian exploration expenditures directed at gold in those years. The result of the heavy emphasis on gold exploration has been an increasing number of gold discoveries, amounting to almost 200 since early 1980. The discovery rate of gold deposits has been accelerating and, if the gold price holds near C$600 per ounce, the number of producing Canadian gold mines (almost 60 in late 1987) may, within a few years, exceed the record of 144 reached in 1940. Because average mine production will be higher than it was in 1940, a total of 144 producing Canadian gold mines would result in annual gold output well above the record 166 t produced in 1941.

This success story does not extend to the base metals. Although some new base-metal deposits have been discovered in recent years, none has as yet proved to be of major size. If Canada is to maintain today's production levels of copper, zinc, and lead into the late 1990s and beyond, some major new deposits of these metals will have to be found soon. More vigorous exploration for these base metals is needed now, because years of exploration are required to come up with a major discovery and it takes another six years or so to develop it into an operating mine (see also Chapter "Canadian Mine Reserves, Development and Promising Deposits").

OUTLOOK

Canadian mineral exploration expenditures will likely remain high in 1988 relative to the historical trend (Figure 1):

i) the momentum of successful exploration for gold in recent years is likely to maintain the gold rush for some time yet, and

ii) corporate profitability will be notably improved thanks to the sharp price rises of nickel, copper and lead that started in 1987; many of the major companies that have relied on flow-through funding for exploration in recent years will be in a position to fund 1988 exploration from their own cash flows.

TABLE 1. EXPLORATION ACTIVITIES BY PROVINCE - 1986

	Expenditures On- and Off-Property		Area of New Claims[1]		Surface Drilling	
	($ millions)	(%)	(hectares)	(%)	(metres)	(%)
Newfoundland	12.3	2	258 605	4	53 186	2
Nova Scotia	17.2	3	577 260	10	68 465	2
New Brunswick	10.8	2	44 872	1	45 917	1
Prince Edward Island	-	-	-	-	-	-
Quebec	241.8	40	1 005 046	17	1 323 105	42
Ontario	136.9	22	983 386	17	770 391	24
Manitoba	26.4	4	301 974	5	152 603	5
Saskatchewan	36.8	6	467 051	8	215 021	7
Alberta	3.0	1	48 664	1	11 723	-
British Columbia	63.1	10	1 613 775	28	271 319	9
Yukon Territory	27.3	4	176 962	3	83 142	3
Northwest Territories	35.3	6	360 361	6	153 477	5
Total	610.9	100	5 837 956	100	3 148 349	100

Sources: For expenditures and drilling: Federal-Provincial Field Expenditure Survey.
For claim areas: provincial and territorial mining recorders.
[1] Excludes coal.
- Nil.

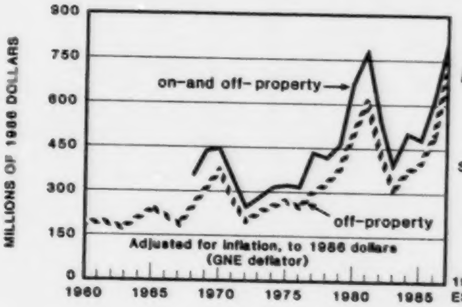
TABLE 2. TYPES OF COMPANIES ENGAGED IN EXPLORATION - 1985 AND 1986

	Expenditures		Surface Drilling	
	1985	1986	1985	1986
	($ millions)		(metres)	
Senior companies (i.e., those with a producing mine in Canada and their affiliates)	260 (53%)	269 (44%)	1 414 952 (57%)	1 603 100 (51%)
Oil companies (excluding the above)	48 (10%)	9 (1.5%)	112 945 (5%)	25 192 (1%)
Foreign companies (excluding the above)	36 (7%)	39 (6.5%)	186 555 (8%)	173 852 (5%)
Others (mainly junior mining companies)	147 (30%)	294 (48%)	748 880 (30%)	1 346 205 (43%)
Total	491 (100%)	611 (100%)	2 463 332 (100%)	3 148 349 (100%)

Sources: Federal-Provincial Field Expenditures Survey and Statistics Canada "Annual Survey on Exploration, Development, Capital and Repair Expenditures".

Figure 1

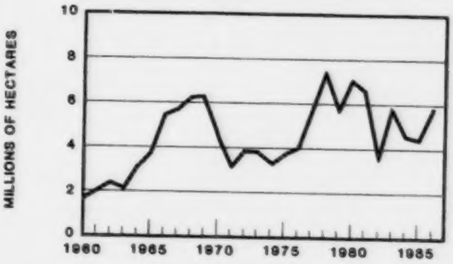
MEASURES OF EXPLORATION ACTIVITY



(a)

EXPENDITURES ON MINERAL EXPLORATION (All minerals except oil and gas)

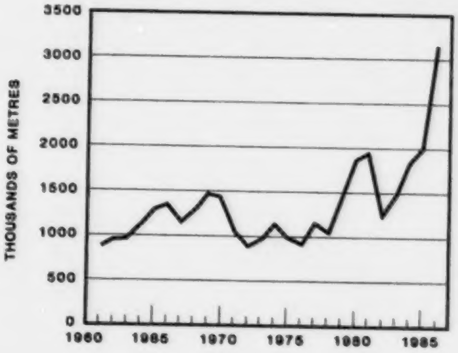
SOURCES: Statistics Canada's Annual Survey of Exploration, Development, Capital and Repair Expenditures (Catalogue 61-216) and Federal-Provincial Exploration and Development Survey.



(b)

AREA OF MINING CLAIMS AND CLAIM BLOCKS RECORDED

SOURCE: Provincial and Territorial Mining Recorders.



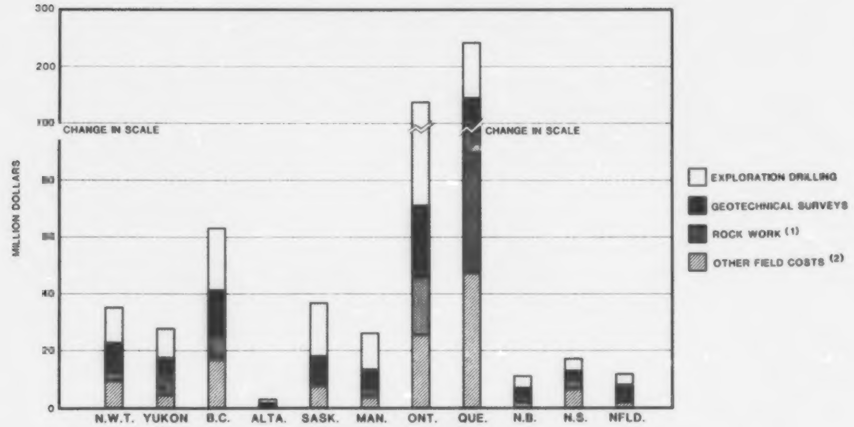
(c)

SURFACE DIAMOND DRILLING (All minerals except oil and gas)

SOURCES: Statistics Canada (Catalogue 26-201) and Federal-Provincial Exploration and Development Survey.

FIGURE 2

EXPLORATION EXPENDITURES BY PROVINCE AND TERRITORY - 1986
Field Work - Physical Work and Surveys

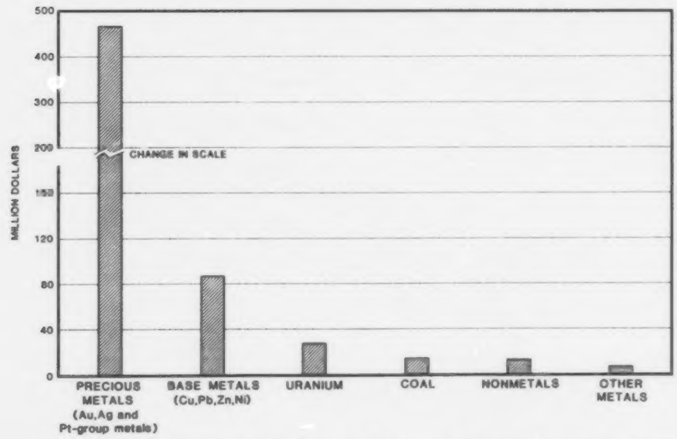


(1) SUCH AS STRIPPING, TRENCHING, SHAFT-SINKING AND UNDERGROUND WORK.
(2) SUCH AS FIELD SUPERVISION AND LINE CUTTING.

SOURCES: Federal-Provincial Field Expenditure Survey and Statistics Canada "Annual Survey on Exploration, Development, Capital and Repair Expenditures".

FIGURE 3

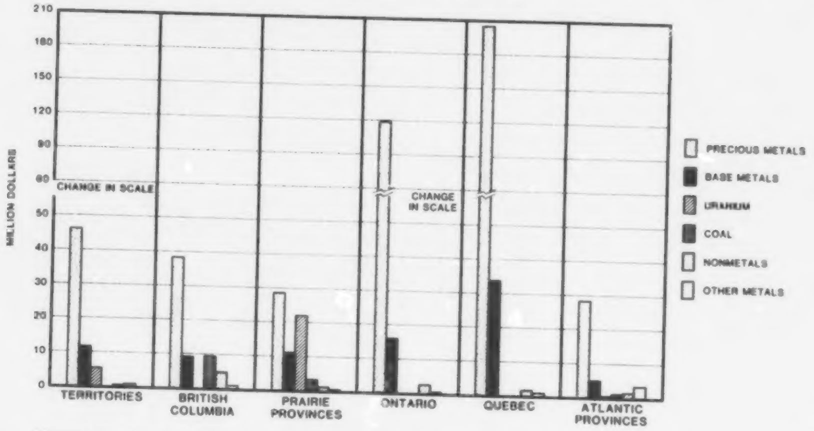
EXPLORATION EXPENDITURES BY COMMODITIES SOUGHT - 1986
Field Work - Physical Work and Surveys



SOURCES: Federal-Provincial Field Expenditure Survey and Statistics Canada " Annual Survey on Exploration, Development, Capital and Repair Expenditures"

FIGURE 4

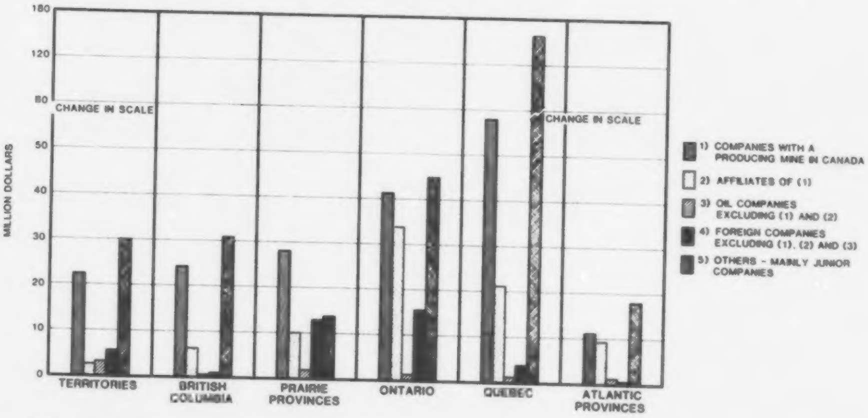
REGIONAL EXPLORATION EXPENDITURES BY COMMODITIES SOUGHT - 1986
Field Work - Physical Work and Surveys



SOURCES: Federal-Provincial Field Expenditure Survey and Statistics Canada "Annual Survey on Exploration, Development, Capital and Repair Expenditures".

FIGURE 5

REGIONAL EXPLORATION EXPENDITURES BY TYPES OF COMPANIES - 1986
Field Work - Physical Work and Surveys

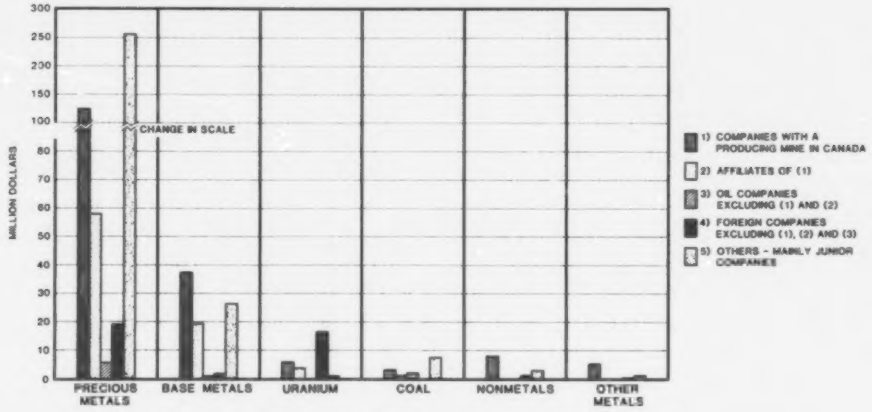


SOURCES: Federal-Provincial Field Expenditure Survey and Statistics Canada "Annual Survey on Exploration, Development, Capital and Repair Expenditures".

FIGURE 6

EXPLORATION EXPENDITURES BY TYPES OF COMPANIES AND COMMODITIES - 1986

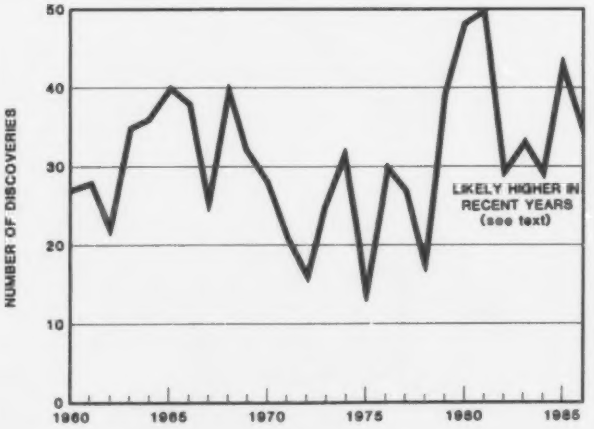
Field Work - Physical Work and Surveys



SOURCES: Federal-Provincial Field Expenditure Survey and Statistics Canada "Annual Survey on Exploration, Development, Capital and Repair Expenditures".

FIGURE 7

CANADIAN DISCOVERIES OF METAL-BEARING DEPOSITS 1960 - 1986



SOURCE: EMR

Aluminum

G. BOKOVAY

The strengthening of metal prices was one of the most significant developments affecting the western world aluminum industry during 1987. While providing a long awaited boost to profitability, particularly for the North American industry, prices have been extremely volatile in response to speculative activity and economic uncertainty.

Volatility and generally higher aluminum prices may have some dampening affect on consumption but it is expected that overall demand will remain relatively strong during 1988. Combined with the prospect that aluminum supplies will remain tight for some time, the short-term outlook is for prices to remain above levels recorded in recent years although significantly below the highs achieved in 1987.

Higher prices in 1984 stimulated a significant increase in production. It is unlikely that this will be repeated in the near term since there is only limited capacity which can be brought back on stream in the United States while in Europe, the appreciation of local currencies in relation to the U.S. dollar will continue to exert pressure to reduce capacity.

Higher dollar prices for aluminum have provided a temporary reprieve for U.S. smelters but the geographical rationalization of the aluminum industry from areas of higher energy costs to areas of abundant energy supplies will continue. In this regard, several new aluminum projects were either announced or confirmed for Venezuela. In Canada, improved market conditions resulted in the reinstatement of one aluminum project in Quebec while preliminary plans for at least one additional project are under consideration.

CANADIAN ALUMINUM INDUSTRY

Three companies produce primary aluminum in Canada: Alcan Smelters and Chemicals Limited, a subsidiary of Alcan Aluminium Limited; Canadian Reynolds Metals Company, Limited, a subsidiary of Reynolds Metals Company of the United States; and Aluminerie de Bécancour Inc. (A.B.I.), a joint venture of Pechiney S.A. of France, Reynolds Metals Company and Alumax Inc. of the United States, and the Government of Quebec through Société générale de financement du Québec (SGF).

Alcan has smelters at Jonquière, Grande Baie, Isle Maligne, Shawinigan and Beauharnois, Quebec, and at Kitimat, British Columbia, with a combined capacity of 1 075 000 t/y. Canadian Reynolds operates one smelter at Baie Comeau with a capacity of 272 000 t/y. A.B.I.'s new smelter at Bécancour, Quebec has a designed capacity of 230 000 t/y.

At the end of 1987, all Canadian smelters were operating at capacity, with the exception of Alcan's Arvida works in Jonquière where approximately 88% of the plant's 432 000 t capacity was being utilized, and the company's 84 000 t/y Shawinigan smelter which was closed at the end of October following a lock-out of workers belonging to the Confederation of National Trade Unions (CNTU). The lock-out was precipitated by several work stoppages staged by the 460 union employees to protest lagging contract negotiations. The previous contract for these workers expired on August 31, 1987. Despite the appointment of a conciliator in mid-December, the two sides were unable to reach an agreement by year-end.

Alcan is involved in labour negotiations at several other aluminum plants in Quebec where contracts also expired at the end of August. The approximately 6000 unionized employees at these smelters, members of the Federation des Syndicats du Secteur d'Aluminium, have yet to declare any work stoppages.

Alcan is the only domestic producer of alumina, the principal raw material for aluminum metal production. The company's refinery, which is located at Jonquière, Quebec, has a capacity of approximately

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1.2 Mt/y of metallurgical and commercial grade alumina. At present, bauxite requirements for this facility are imported principally from Brazil, Guinea, Guyana and Sierra Leone. Alumina production at Jonquière, which totalled 1 015 000 t in 1986, is consumed at Alcan's reduction facilities in Quebec, supplemented with alumina principally from Jamaica. The company's Kitimat plant is supplied with alumina mainly from Australia.

Alumina for the Canadian Reynolds smelter in Baie Comeau is imported principally from the United States while Aluminerie de Bécancour is supplied from Australia.

Canadian production of primary aluminum products increased during 1987 to an estimated 1.53 Mt from 1.36 Mt in 1986. Canadian exports of primary smelter products increased to 861 072 t during the first nine months of 1987 from 851 589 t for the same period in 1986. Exports to the United States totalled 645 610 t in the first nine months compared to 650 942 t for the same period in 1986. Meanwhile, shipments to the Asian market increased to 147 749 t from 133 041 t.

As a result of an improvement in aluminum prices, Alcan Aluminium Limited reported a consolidated net income of US$120 million for the quarter ending September 30, 1987 compared to $62 million for the same period in 1986. For the first nine months of 1987, net income was $297 million versus $216 million in 1986. In addition to the turnaround in the market, Alcan attributed the improvement to the company's continuing commitment to cost reduction.

In May 1987, Alcan announced that it would proceed with construction of the first phase of its Laterrière smelter in Quebec. The project, which was shelved in 1985 due to deteriorating aluminum market conditions, has been scaled back to 200 000 t/y capacity from an initial planned capacity of 248 000 t/y. With the planned closure of an equivalent amount of older inefficient capacity at the company's existing smelter at Jonquière, there will be no net increase to the size of Alcan's operations.

Alcan expects that the new smelter will cost approximately US$450 million, significantly less than estimated for the original proposal. In addition to its smaller size, the company has reduced costs by utilizing an enhanced Grande Baie reduction technology rather than the new Alcan 275 technology which was originally proposed.

Alcan expects that the new smelter will take between 5 and 7 years to complete. The first phase, which will consist of between 50 000 and 60 000 t/y capacity and cost US$150 million, is expected to begin production in 1989. While the replacement of older potlines at Jonquière could result in the elimination of up to 500 permanent jobs, the company expects that any reduction in its labour force will be handled by normal attrition.

Also in the Lac Saint Jean region of Quebec, Alcan inaugurated a new 40 000 t/y aluminum fluoride plant in June 1987. The plant, which cost C$135 million, is the largest plant of its kind in the western world. Aside from supplying its own aluminum reduction facilities in eastern Canada with aluminum fluoride, a chemical used to lower the temperature of the electrolytic bath during smelting, Alcan supplies other Canadian and U.S. producers.

In July 1987, Alcan announced that it had completed the acquisition of CAE Die Cast, a division of CAE Industries Ltd. This operation, which produces aluminum semi-permanent mold castings for the automotive industry, is located in St. Catharines, Ontario.

In September, Alcan announced that it was closing its aluminum foil processing plant (Muskoka works) at Bracebridge, Ontario as part of a company-wide rationalization of foil-rolling facilities. The company said that the closure was unrelated to an ongoing strike at the plant but rather to the fact that the small size of the Canadian market did not warrant modernization of this facility. Also during 1987, Alcan sold its Canada Foils division to BRP/Tripak of Montreal and Toronto. Alcan said that this sale was in line with its policy of redeploying assets to other businesses.

In September 1987, the federal Department of Fisheries and Oceans and Alcan reached an out of court settlement of a dispute involving control of water flows on the Nechako and Nanika Rivers in west-central British Columbia. While the company sought the right to increase its hydro electric capability in the area under terms of a water licence agreement granted it by the province of British Columbia in 1950, the federal government sought a ruling to uphold its authority to regulate water flows and ultimately salmon stocks. Under the terms of the agreement, Alcan will be able to increase the power generating capacity at its Kemano power station by about 520 megawatts and thus be able to proceed with long-term development plans which presumably will include the construction of a new aluminum smelting capacity in British Columbia.

On June 15, a fire at the Cap-de-la-Madeleine fabricating plant of Reynolds Aluminum Company of Canada Ltd. destroyed a heavy-gauge foil mill, an annealing furnace and other equipment. Despite the loss of some capacity, the company was able to maintain production at the facility.

With the commissioning of the remaining 480 pots on February 13, 1987, the new $1.1 billion smelter of Aluminerie de Bécancour Inc. (A.B.I.) was fully completed. Operating capacity is 230 000 t/y and the smelter employs about 750 persons. While ownership had been 50.1% Pechiney of France, 24.95% Alumax Inc. of the United States and 24.95% Albecour Inc., a subsidiary of SGF of Quebec, Pechiney concluded the sale of half its share to Reynolds Metals Company on July 27, 1987. It was reported that the purchase price was US$87.5 million in cash and the assumption of $142.5 million of debt. A feasibility study is being conducted for a third 115 000 t/y potline, estimated to cost $500 million. A decision on this project is expected in 1988.

At the end of 1987, it was reported that SGF was undertaking preliminary talks with a number of foreign companies for a new aluminum smelter project in Quebec. Code-named Alouette, the smelter would have a capacity of 200 000 t/y and cost an estimated $1.1 billion. Potential sites for this plant include Sept-Îles, Lauzon and Deschambault.

WORLD DEVELOPMENTS

Non-socialist world consumption of primary aluminum in 1987 is expected to have been about 13.35 Mt, up from the 13.10 Mt recorded in 1986. Preliminary data indicate that primary aluminum production in 1987 was about 12.88 Mt, compared with 12.19 Mt in 1986. Despite this significant increase in production, world smelting capacity actually decreased marginally during the year.

According to a press report based on a study by Anthony Bird and Associates, the average operating cost for the production of aluminum in the non-socialist world increased in 1987 to US47.3¢/lb. from 45.8¢ in 1986. On a country-by-country basis, Venezuela had the lowest cost at 34¢ while the United States at 54¢ was the highest cost producer. Canada, Australia, Brazil and France were reported to have costs of between 41¢ and 44¢ while Norway and West Germany had costs of 48¢ and 49¢, respectively. While the United States had the highest overall cost of production, the report suggested that costs for several plants in Europe were equal to or approaching those of the United States. For the entire non-socialist world, the report estimated that at prices above 70¢/lb., approximately 13.6 Mt of capacity could be operated profitably. According to the same report, the cost of producing alumina continued to decline, falling to $156/t in 1987 from $159 in 1986 and $206 in 1982.

During 1987, higher dollar aluminum prices helped the U.S. smelting industry stage a remarkable recovery. Plagued by significant underutilization of capacity in recent years, most companies brought idled potlines back on-stream during the year in response to more favourable market conditions. Specific restarts included 40 000 t/y at the Eastalco smelter of Alumax Inc. at Frederick, Maryland in April, 80 000 t/y at Aluminum Company of America (Alcoa) plants at Badin, North Carolina, and Warrick, Indiana between April and June, one 22 700 t/y potline at the Troutdale, Oregon smelter of Reynolds Metals Company in May and another in October and about 50 000 t/y of capacity at the Mead, Washington smelter of Kaiser Aluminum & Chemical Corporation during the first half of 1987. In addition, National Southwire Aluminum Co. restarted about 18 500 t/y of capacity at its Hawesville, Kentucky smelter between August and the end of October while Kaiser announced that it would reactivate a similar amount of capacity at its Ravenswood, West Virginia smelter beginning in December. In July, Alcan initiated the restart of one 54 400 t/y potline at its Sebree, Kentucky smelter while reactivation of the last idled potline of the same size at the facility was scheduled for the first quarter of 1988. In October, Alcoa announced that it was restarting 105 000 t/y of capacity at its Rockdale, Texas smelter beginning in November while in late December the company reported that it would restart 40 000 t/y of capacity at its Alcoa, Tennessee plant. These last Alcoa start-ups are particularly significant for the U.S. aluminum industry in that they represent part of the company's "permanent" cutback of U.S. smelting capacity first announced in 1985.

At the end of June, Alcoa concluded the sale of its 115 000 t/y Vancouver, Washington smelter to a newly formed company known as Vanalco Inc. The plant, which was commissioned in 1940, was closed in June 1986. Vanalco expected to have three of the plant's five potlines in service by the end of October with a fourth scheduled for reactivation in the first quarter of 1988.

In January 1988, Alcoa announced that it was planning to phase out operations at its bauxite mine and alumina refinery, located at Bauxite, Arkansas. The closures, which will be completed by October 1988, will affect about 175 employees.

In August, another new company, Columbia Aluminum Corp., completed the purchase of the idled 157 000 t/y Goldendale, Washington smelter owned by Commonwealth Aluminum Corp., a subsidiary of Comalco Limited of Australia. Commonwealth ceased production at the smelter in February 1987 following unsuccessful attempts to find a buyer. The first of three potlines at the plant was restarted at the end of August. Columbia plans to operate the Goldendale plant as a toll facility. It has been reported that Hydro Aluminium A.S. of Norway will take a major share of initial production.

At the end of June, Kaiser Aluminum announced that it would write down several idled production facilities in the United States. This included the remaining 105 000 t/y capacity at the company's Chalmette, Louisiana smelter and a 37 000 t/y potline at Ravenswood, West Virginia.

In November, it was reported that Clarendon Ltd., an associated company of Marc Rich & Co. AG, intended to purchase a 25% equity position in Alumax's 181 500 t/y smelter at Mt. Holly, South Carolina. During 1987, Clarendon had a toll contract covering 50% of production from this facility although it may have taken up to 75% of total output.

Elsewhere in the United States, Alcan announced in October that it was discontinuing the production of several sheet products at its Terre Haute, Indiana fabricating plant. Following the implementation of these changes, which will affect 460 workers, the facility will concentrate on the production of aluminum foil for the packaging and rigid container markets. Alcan also announced in December that it will build a new US$50 million plant in the midwestern United States to recycle used aluminum cans. The new plant will have a capacity of about 109 000 t/y (6 billion cans). At present, the company's sole recycling center in the United States is a 54 000 t/y plant at Greensboro, Georgia.

In October, Alcoa commissioned a new US$150 million continuous cold mill at Alcoa, Tennessee. When brought to full capacity, the facility will produce more than 700 million lb./y of stock. In December, Kaiser Aluminum announced that it would spend US$29.5 million to modernize its Trentwood, Washington rolling mill.

On July 14, 1987, Southwire Co. petitioned the U.S. International Trade Commission to investigate the alleged dumping and subsidization of Venezuelan aluminum rod imported into the United States. While a preliminary determination by the Commerce Department in the matter of possible dumping and a final determination in the case of subsidization were expected on December 21, 1987 decisions have been postponed until February 1 and March 7, 1988 respectively. During 1987, there were reports in the United States of a possible complaint by domestic can sheet producers against imports from Japan. However, with the strength of the yen and a reduced volume of exports to the United States, the continued pursuit of such trade action appears unlikely.

During 1987, it was reported that the Battelle Memorial Institute of Columbus, Ohio had developed a new inert electrode for aluminum production which could reduce energy consumption by 30% and which is consumed much more slowly than existing carbon based electrodes. The new electrode is made from a metallic ceramic compound.

In October, Alcoa announced that it planned to reassume full operational and commercial responsibility for its Clarendon alumina refinery in Jamaica, effective February 1, 1988. Following Alcoa's closure of the plant in February 1985, the Jamaican government reopened the facility in July of that year. It has been reported that the

Jamaican government is trying to obtain guarantees from Alcoa on production levels, expansion plans and job security at the facility.

At the beginning of 1988, it was reported that Alcan and the Jamaican government were holding discussions on the possible reopening of idled capacity at the company's Ewarton alumina plant. The company has stated that it was prepared to increase alumina production in exchange for a reduction in Jamaica's bauxite levy.

In December, the Jamaican government revoked the mining lease held by Alumina Partners of Jamaica (Alpart) which is owned by Kaiser Aluminum and Reynolds Metals. Alpart's operations in Jamaica were shut down in 1985 due to depressed market conditions.

In Surinam, the Suriname Aluminum Company (Suralco), a subsidiary of Alcoa, was forced to close its 60 000 t/y smelter in January 1987 after guerrillas destroyed two electric transmission lines. In July, Alcoa announced that it was writing down 50% of the plant's capacity. Guerrilla attacks also forced the closure of Suralco's Moengo bauxite mine during the first half of 1987 while the country's alumina refinery owned by Suralco and Billiton B.V. was closed in March as a result of labour sabotage.

During 1987, the Venezuelan government announced an ambitious plan for its aluminum industry whereby its primary smelting capacity will be increased from 405 000 t/y to over 1.4 Mt/y by 1994. The country's largest producer, Industria Venezolana de Aluminio CA (Venalum), with a capacity of about 280 000 t/y, is expected to complete a 175 000 t/y expansion to its existing smelter by 1989. At the end of 1987, it was reported that Venalum and Italimpianti of Italy will build a new 360 000 t/y smelter for completion in the mid-1990s.

Venezuela's other producer, Aluminio del Caroni SA (Alcasa) with an existing capacity of about 125 000 t/y, is expected to complete a new 90 000 t/y potline in 1989. During 1987, Alcasa signed a letter of intent with Austria Metall A.G. for a new 180 000 t/y smelter, to be completed in the early 1990s. Other minor participants in this project will include Reynolds Metals and the Venezuelan government through the Corporacion Venezolana de Guayana (CVG).

Also during 1987, it was announced that Suramericana de Aleaciones Laminadas (SURAL), the Venezuelan wire rod and cable producer, would build a new 120 000 t/y smelter. In January 1988, it was reported that ownership of the new smelter would be SURAL 40%, Alcoa 40% and CVG 20%. Completion of this facility is expected by the end of 1989. Another aluminum project, called Alisa, was also announced in Venezuela during 1987. This project, which will be built in three stages of 33 500 t/y capacity each, is expected to be completed by 1991. Participants in this development will include Venezuelan government agencies, private Venezuelan interests and foreign companies. It has been reported that Hydro Aluminium will supply the technology.

Although Venezuela has depended on foreign bauxite for its aluminum industry, this will change as the new mine of Bauxita Venezolan CA (Bauxiven), which commenced production during 1987, is brought fully on-stream. In line with the planned increase in smelting capacity, current plans are to produce 8 Mt/y by 1993.

In addition to bauxite, the country's alumina producer Interamericana de Alumina CA (Interalumina) plans to double the capacity of its existing refinery to 2 Mt/y by 1991 and is considering the construction of a second facility.

With existing electric power rates of about US7 mills/kWh, the Venezuelan aluminum industry enjoys some of the lowest energy costs in the world. Although the construction of a new generating capacity will require some increase in rates, it is expected the new aluminum smelter projects will receive electric power at about US10 mills/kWh for an initial five years, increasing to 15 mills over the next ten years.

In Brazil, drought conditions during 1987 resulted in energy rationing to at least three aluminum smelters. In addition, an acute shortage of power forced Alcoa Aluminio S.A. and Billiton Metais SA to shelve plans for the expansion of their Alumar aluminum smelter from 245 000 t/y to 380 000 t/y.

In October 1987, work began on phase two of the Aluminio Brasileiro SA (Albras) aluminum project during which capacity will double to 320 000 t by 1991. The project is controlled 51% by Companhia Vale do Rio Doce (CVRD) and the Japanese consortium

Nippon Amazon Aluminum Co. (NAAC). During 1987, it was reported that CVRD is continuing to seek new partners for its 800 000 t/y Aluminio do Norte do Brasil S.A. (Alunorte) alumina project which was shelved in 1986 when NAAC withdrew support due to low world alumina prices.

In the People's Republic of China, it was reported that the first 100 000 t/y phase of a new Qinghai aluminum smelter began production at the end of 1987. The second phase of the smelter consisting of another 100 000 t/y capacity is now under construction. With the completion of these and several other smelters now under construction including Shanxi, Qingtongxia, and Baotou, the Chinese government expects to nearly double the 1985 level of aluminum production by 1990.

In July, it was announced that work was beginning on a new 100 000 t/y aluminum rolling mill and extrusion plant in the port city of Qinghuangdao. The facility, which will take three years to complete, is a joint venture between the China International Trust Investment Corp. (Citic) and Aluvic, the Australian body owned by the Victoria government.

During 1987, India's goal of achieving self sufficiency in aluminum production moved closer to reality with the commencement of production at the new Angul smelter in Orissa state in May. The facility, which is owned by the National Aluminium Co. Ltd. (Nalco), is expected to reach its full design capacity of 218 000 t/y by 1991.

Despite this increase in capacity, India's aluminum industry is periodically hampered by power shortages. At the end of the year, it was reported that over a quarter of the country's aluminum capacity had been affected by power cuts during the second half of 1987.

During 1987, Umm Al Quwain Aluminium Company (UMALCO) announced that it will proceed with the construction of a new 240 000 t/y smelter for the United Arab Emirates state of Umm Al Quwain. It has been reported that the China National Metals and Minerals Import and Export Corporation of Beijing and China Everbright Holdings Co. of Hong Kong will take a 10% equity position in the project as well as an estimated 78 000 t/y of output from the facility. Production is expected to begin in 1990.

It was reported in December that Comalco Limited of Australia and the U.S.S.R. will undertake a feasibility study for an integrated aluminum complex on the Pacific coast of the Soviet Union. It was also reported at the end of 1987 that Hydro Aluminium and the Soviet Union were discussing a possible joint venture alumina project in the Kola Peninsula and the sale of smelting technology to the U.S.S.R.

In December, a three-day wild-cat strike at Spain's INESPAL aluminum smelter in San Ciprian resulted in extensive damage to the facility. A company spokesman stated that it could take up to six months to bring the plant back to its full operating capacity of 195 000 t/y.

In West Germany, Alcan closed its 44 000 t/y Ludwigshafen aluminum smelter at the end of March due to high operating costs. This included electric power costs of up to US40 mills/kWh. At the time of the closure, the plant was operating at only 50% of capacity. Alcoa announced in September that it would close its 140 000 t/y alumina refinery at Ludwigshafen in March 1988, also due to high operating costs.

In November, Kaiser Aluminum completed the sale of its subsidiary Kaiser Aluminium Europe Incorporated (KAE) to Hoogovens Groep BV of the Netherlands. The transaction included a 75 000 t/y smelter at Voerde, West Germany, along with fabricating plants in Germany, Belgium and Switzerland.

Elsewhere in Europe, construction was scheduled to begin in the second half of 1987 on Greece's new 600 000 t/y alumina refinery. The project, which was originally planned for Delphi, has been moved for environmental reasons to Aghia Efthynia in the province of Fokida.

USES

Aluminum's low density, high strength and corrosion resistance make it suitable for use in alloyed and unalloyed forms in a wide variety of products. In the building and construction industry, major uses for aluminum include residential siding, window and door frames, screens, awnings and canopies. In the transportation sector, aluminum is widely used in the manufacture of buses, trucks, trailers and semi-trailers and is the principal metal in aircraft. In this regard, new aluminum-lithium alloys promise to deliver significant weight savings over traditional aircraft alloys. However, the high price of such alloys, which are currently as much as three times the price of conventional aircraft alloys, prohibits their widespread application at this time. Aluminum is also being increasingly used in passenger cars as manufacturers move to reduce the weight of their vehicles.

Alcan has developed an aluminum structured vehicle technology which can reduce the weight of the basic frame by up to 50%. The company has stated that the technology, which utilizes adhesively bonded sheet aluminum, is suitable for modern automobile manufacturing methods and plants. During 1987, Ford Motor Company announced that it will develop its own aluminum frame for passenger cars based on aluminum extrusions and continuous welding techniques.

Another transportation related use for aluminum which holds some promise is a new lightweight closed deck system developed by Alcoa for bridges. This system represents a long term replacement option for deteriorating steel and concrete decks in North America.

In the electrical field, aluminum extensively replaced copper in wiring and power transmission in the 1960s but, while it has maintained the market for power transmission applications, local restrictions and consumer resistance have substantially lessened the demand for aluminum in electrical wiring. Aluminum has however gained acceptance in various communications and computer applications.

Another application for aluminum is the new aluminum air cell which produces electricity from the oxidation of aluminum metal. While this battery is still in development, it promises to deliver more energy than conventional batteries.

PRICES AND STOCKS

Aluminum prices on the London Metal Exchange (LME) increased steadily through the first half of 1987 on the strength of improved market fundamentals, including buoyant demand and falling inventory levels. In the second half, aluminum prices, particularly for spot metal, increased sharply due to speculative activity combined with the threat of actual or perceived metal shortages with the possibility of labour disruptions at Alcan's Quebec smelters where labour contracts expired at the end of August. While significantly higher overall, aluminum prices in the second half were extremely volatile, the result of speculative influences and also due to reversals on world stock markets that heightened fears of a major downturn in the western economies.

The price of standard grade aluminum ingot (99.5% purity) on the LME, which averaged US53.1¢/lb. in January 1987, increased steadily through the first half of the year reaching a peak of 85.2¢ on August 21. While prices eased somewhat at the end of August, reaching a low of 71.1¢ on September 2, prices strengthened once again during the remainder of the month and into October reaching a high for the year of 97.7¢, the highest level in seven years. During November, prices eased somewhat although prices strengthened once again during December, closing the year at about 90¢. The average LME price during 1987 was US71.0¢ compared to 52.2¢ in 1986.

In March 1987, the LME announced the establishment of a new high grade (99.7% purity) aluminum contract denominated in U.S. dollars. Three month trading began on June 1, with the first prompt date of September 1. The basic reason for the introduction of the new contract was to increase the attractiveness of the LME since high purity aluminum had become more representative of the market in terms of both its availability and use. Despite the possible benefits of the new contract, trading through the summer was characterized by thin volumes and low metal stocks. In September, the LME intervened by announcing that the Exchange would cease trading standard grade material on December 21, 1988. It had been reported that this decision was taken in the belief that a switch to high grade material would help to eliminate the almost perpetual backwardation of the LME aluminum contract.

The International Primary Aluminum Institute reported that total inventories of aluminum (including scrap, primary and secondary ingot, metal in process and finished mill products) in November 1987 stood at 3.073 Mt compared to 3.664 Mt in November 1986. Primary metal stocks also declined over the same period from 1.861 Mt to 1.386 Mt.

During 1987, spot alumina prices strengthened significantly with transactions in the second half of the year reported in the US$160 to $170/t range from a range of US$130 to $140 at the end of 1986.

At the end of November, the International Bauxite Association (IBA) announced that it intended to extend its existing pricing system for bauxite and alumina through 1988. The minimum recommended C.I.F. price for base grade metallurgical bauxite is 2.5% to 3.5% of an IBA reference price for aluminum ingot while the C.I.F. price for alumina is 14% to 18% of the same reference price.

OUTLOOK

There are few if any totally new frontiers that offer potential for dramatic increases in aluminum consumption. Nevertheless, aluminum consumption is expected to grow at an average annual rate of about 1.5% in the next decade. This forecast presumes that a major recession will be avoided in 1989 and that some normalcy returns to the world's currency markets.

Despite the introduction in recent years of a variety of substitutes, recent breakthroughs in the development of advanced aluminum based alloys/materials and more efficient fabricating techniques, will allow the aluminum industry to hold its own in an intensely competitive environment.

One of the most promising areas for future aluminum growth is the transportation goods sector. While the list of possible new or expanded applications for aluminum in this area is extensive, the most important are expected to be railway cars, dump trucks and automobiles. At the end of 1987, Hydro Aluminium unveiled a sports car containing 120 kg of aluminum, about three times the average weight of the metal currently used by automobile manufacturers.

The packaging sector still offers some growth potential in the United States, particularly for aluminum beverage cans, but is constrained by a higher rate of recycling and thinner walled products. Whereas about one half of the 75 billion aluminum beverage cans were expected to be recycled in the United States during 1987, the recycling rate is forecast to rise to about 70% by 1995.

During 1987, several new developments were announced in the use of aluminum in food packaging that should at least protect the metal from loss of market share. This includes a new packaging method developed for microwaves by Alcan, a resealable aluminum beverage can developed by Reynolds Metals and a plastic-aluminum composite food can developed by Showa Denko K.K. and Taiyo Fishery Co. of Japan that maintains the taste of food for longer periods.

Despite continued strong demand and tightness of metal supplies, it is expected that the average price for aluminum during 1988 will be about US70¢. While consumers withstood sharply higher prices during the second half of 1987, prolonged exposure to such conditions will prompt substitution to other materials where possible.

In the longer term, the addition of significant new, low-cost capacity, particularly in Venezuela, combined with the closure of high cost smelting capacity in Europe and the United States will exert considerable downward pressure on aluminum prices. Therefore, it is expected that aluminum will trade in the range of 58.5¢ to 68.5¢ (constant 1987 U.S. cents) in the next decade.

It is expected that some additional aluminum capacity will be built in Canada during the 1990s as market conditions improve. Canada remains one of the most attractive locations for new investment in the aluminum industry due to its abundant low cost electric power and geographical proximity to the large U.S. market.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
CANADA					
32910-1	Bauxite	free	free	free	free
35301-1	Aluminum pigs, ingots, blocks, notch bars, slabs, billets, blooms and wire bars, per pound	free	free	5¢	free
35302-1	Aluminum bars, rods, plates, sheets, strips, circles, squares, discs and rectangles	free	2.1	9	free
35303-1	Aluminum angles, channels, beams, tees and other rolled, drawn or extruded sections and shapes	free	8.0	30	free
35305-1	Aluminum pipes and tubes	free	8.0	30	free
92820-1	Aluminum oxide and hydroxide; artificial corundum (this tariff includes alumina)	free	free	free	free
UNITED STATES (MFN)					
417.12	Aluminum compounds: hydroxide and oxide (alumina)		free		
601.06	Bauxite		free		
618.01	Unwrought aluminum of uniform cross-section throughout its length, the least cross-sectional dimension of which is not greater than 0.375 inch, in coils, per pound		2.6		
618.02	Other unwrought aluminum, aluminum other than alloys of aluminum, per pound		free		
618.04	Aluminum silicon, per pound		2.1		
618.06	Other aluminum alloys, per pound		free		
618.10	Aluminum waste and scrap, per pound		2.0		

Sources: Customs Tariff 1987, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1987), USITC Publication 1910; U.S. Federal Register Vol. 44, No. 241.

TABLE 1. CANADA, ALUMINUM PRODUCTION AND TRADE, 1985-87

	1985		1986		1987P	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Production	1 282 316	..	1 355 161	..	1 530 000	..
Imports					(Jan.-Sept.)	
Bauxite ore						
Guyana	398 428	18 793	236 736	13 436	288 350	11 320
Guinea	105 398	9 438	314 929	14 590	300 558	11 222
Brazil	1 401 962	58 304	1 161 653	43 447	207 403	7 379
Sierra Leone	0	0	241 069	7 806	254 468	7 351
United States	43 824	7 193	48 084	8 900	46 010	6 563
France	0	0	0	0	63 554	2 736
Turkey	0	0	0	0	17 706	1 283
Surinam	11 990	626	21 366	1 384	26 265	1 248
Australia	51 724	6 662	30 358	3 915	11 500	1 152
Malaysia	0	0	0	0	43 997	737
Greece	9 183	473	27 610	1 497	10 733	507
Jamaica	0	0	0	0	7 057	222
People's Republic of China	51 497	5 326	31 100	2 903	8 500	216
Denmark	0	0	0	0	2 000	126
French Guyana	200	44	0	0	0	0
Total	2 074 206	106 859	2 112 905	97 879	1 288 101	52 064
Alumina						
Australia	239 107	44 472	501 914	98 758	673 330	127 237
United States	71 990	21 456	237 256	54 524	339 970	67 194
Jamaica	651 687	137 333	618 212	124 447	387 395	66 235
Ireland	28 813	5 309	0	0	120 259	24 877
Japan	286 501	58 458	268 915	57 162	40 446	12 563
Surinam	0	0	0	0	12 323	2 056
France	220	155	167	130	445	390
United Kingdom	2	1	8	4	202	100
Germany, West	180 724	43 001	52 078	17 253	202	98
People's Republic of China	0	0	0	0	35	11
U.S. Virgin Islands	25 038	6 329	0	0	0	0
Netherlands	0	0	36	29	0	0
Venezuela	59 925	6 156	46 013	7 077	0	0
Total	1 544 007	322 670	1 724 599	359 384	1 574 607	300 760
Aluminum and aluminum alloy scrap	53 376	47 489	69 888	61 866	43 646	47 097
Aluminum paste and aluminum powder	1 273	6 481	1 718	8 036	1 436	7 310
Pigs, ingots, shot, slabs, billets, blooms and extruded wire bars	59 743	109 842	64 520	120 422	39 531	72 280
Castings	1 332	16 270	1 350	13 670	964	10 707
Forgings	913	17 104	761	16 754	556	11 696
Bars and rods, n.e.s.	6 966	20 604	7 812	23 060	7 188	21 442
Plates	9 560	32 879	12 228	42 876	9 018	32 334
Sheet and strip up to .025 inch thick	24 732	76 382	35 159	101 018	39 721	1 113 828
Sheet and strip over .025 inch up to .051 inch thick	15 653	54 956	16 191	56 357	12 888	44 057
Sheet and strip over .051 inch up to .125 inch thick	73 273	153 171	51 456	122 872	39 100	93 970
Sheet over .125 inch thick	33 423	77 127	40 289	101 880	32 775	81 000

Foil or leaf	999	3 736	1 834	6 515	2 446	8 494
Converted aluminum foil	..	15 968	..	15 096	..	26 332
Structural shapes	4 234	18 913	5 446	23 534	5 238	23 369
Pipe and tubing	2 611	11 362	3 700	15 615	3 086	12 668
Wire and cable, not insulated	1 765	5 785	3 003	8 824	2 315	7 012
Aluminum and aluminum alloy fabricated materials, n.e.s.	..	89 760	..	104 104	..	85 093
Exports						
Pigs, ingots, shot slabs, etc.						
United States	683 306	108 846	856 978	1 540 771	645 610	1 224 590
Japan	142 210	199 099	102 236	152 565	79 714	133 563
Korea, South	8 028	11 712	27 607	45 583	26 246	47 013
Turkey	36 020	55 995	22 222	36 411	18 120	30 530
Taiwan	22 991	35 978	20 478	34 452	15 020	29 281
Hong Kong	21 289	33 423	23 346	40 314	11 530	21 458
Netherlands	6 119	8 897	6 506	11 544	10 702	18 995
Israel	7 796	13 455	11 201	19 942	6 778	12 215
Thailand	14 287	23 478	5 856	10 201	5 655	11 281
Belgium-Luxembourg	0	0	5 743	7 959	7 088	10 964
Sweden	6 308	9 076	20 487	34 691	5 548	10 495
People's Republic of China	67 656	98 526	19 306	30 892	4 891	8 040
Other	34 779	58 859	41 743	75 348	24 173	47 727
Total	1 050 789	1,636 915	1 163 709	2,040 673	861 075	1 606 150
Castings and forgings						
United States	8 820	74 775	10 987	94 592	7 783	66 997
Total	9 009	83 051	11 155	102 105	7 847	73 091
Bars, rods, plates, sheets and circles						
United States	43 996	115 414	51 853	133 267	60 939	146 027
Total	55 070	138 078	58 713	148 123	72 634	175 116
Foil or Leaf						
United States	1 610	5 062	1 757	5 518	351	1 310
Total	1 642	5 214	1 847	5 885	353	1 314
Fabricated materials, n.e.s.						
United States	9 791	36 770	8 708	33 629	38 782	87 816
Total	12 122	44 064	10 693	43 131	41 704	99 947
Ores and concentrates						
United States	48 643	22 897	40 547	19 736	28 434	14 433
Total	52 577	25 568	45 295	23 021	33 675	17 935
Scrap						
United States	97 668	111 770	101 157	128 945	82 188	115 408
Total	113 277	129 821	123 602	155 365	97 180	137 055

Sources: Statistics Canada; Energy, Mines and Resources Canada.
P Preliminary; .. Not available; n.e.s. Not elsewhere specified.

TABLE 2. CANADA, CONSUMPTION[1] OF ALUMINUM METAL AT FIRST PROCESSING STAGE, 1984-86

	1984	1985	1986P
		(tonnes)	
Castings			
Sand	1 639	1 640	2 000
Permanent mould	12 832	16 180	16 306
Die and other	33 041	31 368	34 607
Total	47 512	49 188	52 913
Wrought products			
Extrusions, including tubing	93 730	92 111	117 432
Sheet, plate, coil and foil	155 242	130 522	153 201
Other wrought products (including rod, forgings and slugs)	72 712	57 286	62 375
Total	321 684	279 919	333 008
Other uses			
Destructive uses (deoxidizer), non-aluminum base alloys, powder and paste	10 053	16 926	19 564
Total consumed	379 249	346 033	405 485
Secondary aluminum[2]	63 401	78 047	60 265

	Metal Entering Plant			On Hand December 31		
	1984	1985	1986	1984	1985	1986
Primary aluminum ingot and alloys	397 794r	314 614	346 093	21 309r	23 050	21 572
Secondary aluminum	51 341r	51 439	50 524	5 224	4 017	2 656
Scrap originating outside plant	76 592	89 969	88 659	4 759	6 126	6 796
Total	525 727	456 022	485 276	31 292	33 193	31 024
Aluminum shipments[3]				90 623	30 041	21 695

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[1] Available data as reported by consumers. [2] Aluminum metal used in the production of secondary aluminum is not included in consumption totals. [3] Aluminum metal shipped without change. Does not refer to shipments of goods of own manufacture.
Note: Revisions reflect changes to company specific data.
P Preliminary; r Revised.

TABLE 3. CANADA, ALUMINUM SMELTER CAPACITY

(as of December 31, 1987)

	Annual tonnes
Alcan Aluminium Holdings Limited	
Quebec	
Grande Baie	171 000
Jonquière	432 000
Isle-Maligne	73 000
Shawinigan	84 000
Beauharnois	47 000
British Columbia	
Kitimat	268 000
Total Alcan capacity	1 075 000
Canadian Reynolds Metals Company, Limited	
Quebec	
Baie Comeau	272 000
Aluminerie de Bécancour Inc.	
Quebec	
Bécancour	230 000
Total Canadian capacity	1 577 000

Source: Compiled from company reports by Energy, Mines and Resources Canada.

TABLE 4. AVERAGE 1987 PRICES

Month	LME Cash[1]	LME Cash[2]	U.S. Market[1]
		(US¢/lb.)	
January	n.a.	53.13	54.60
February	n.a.	58.22	59.45
March	n.a.	62.02	62.55
April	n.a.	63.55	64.97
May	n.a.	64.03	68.90
June	n.a.	66.78	72.55
July	n.a.	74.98	74.24
August	n.a.	82.12	81.67
September	80.67	79.21	80.69
October	89.10	89.03	84.39
November	76.73	76.25	80.16
December	83.29	82.73	83.39
1987 Average		71.00	72.30
1986 Average		52.18	55.87

Source: Metals Week.
[1] High grade 99.7% purity. [2] Standard grade 99.5% purity.
n.a. Not applicable as trading started Sept. 1987.

TABLE 5. ESTIMATED NON-COMMUNIST WORLD PRODUCTION OF ALUMINA

	1982	1983	1984	1985	1986	(Jan.-Sept.) 1987
			(million tonnes)			
Europe[1]	4.46	4.35	5.24	4.87	5.06	3.82
Africa	0.58	0.56	0.55	0.58	0.57	0.40
Asia	1.81	1.89	2.12	2.00	1.66	1.05
North America	5.27	5.07	5.75	4.56	4.07	3.76
Latin America	3.48	4.17	4.60	4.73	5.39	4.34
Oceania	6.63	7.31	8.80	8.80	9.37	7.51
Total	22.23	23.35	27.06	25.54	26.12	20.88
of which nonmetallic uses	1.97	2.06	2.31	2.34	2.39	1.75

Source: International Primary Aluminum Institute.
[1] Excludes Yugoslavia.

TABLE 6. WORLD MINE PRODUCTION OF BAUXITE

	1984	1985	1986
		(000 tonnes)	
Europe			
France	1 529.5	1 529.6	1 379.0
Greece	2 296.2	2 453.8	2 225.0
Spain	7.3	2.4	3.0
Yugoslavia	3 347.0	3 538.0	3 459.0
Total	7 180.0	7 523.8	7 066.0
Africa			
Ghana	49.0	170.0	204.0
Guinea	14 738.0	13 956.0	14 656.0
Sierra Leone	1 041.2	1 184.5	1 242.0
Zimbabwe	22.7	21.0	24.3
Total	15 850.9	15 331.5	16 126.3
Asia			
India	2 078.0	2 268.0	2 338.0
Indonesia	1 003.1	830.5	649.9
Malaysia	680.4	491.9	566.2
Turkey	131.6	213.8	290.7
Total	3 893.1	3 804.2	3 844.8
Americas			
United States	856.0	674.0	510.0
Brazil	6 433.1	5 846.0	6 446.3
Guyana	3 035.6	2 153.2	2 073.9
Jamaica	8 734.9	6 239.3	6 963.9
Surinam	3 374.9	3 738.3	3 730.6
Total	22 434.5	18 650.8	19 724.7
Australasia			
Australia	31 537.0	31 839.0	32 432.0
Total	**80 895.5**	**77 149.3**	**79 193.8**
Monthly Average	6 741.3	6 429.1	6 599.5
Other countries			
China	2 000.0	2 100.0	2 200.0
Hungary	2 994.0	2 815.0	3 022.3
Romania	460.0	460.0	500.0
U.S.S.R.	6 200.0	6 400.0	6 275.0
Total	11 654.0	11 775.0	11 997.3
World Total	**92 549.5**	**88 924.3**	**91 191.1**

Source: World Bureau of Metal Statistics.

TABLE 7. WORLD PRODUCTION OF ALUMINUM

	1984	1985	1986
		(000 tonnes)	
Europe			
France	341.5	293.2	321.8
Germany, F.R.	777.2	745.4	763.7
Italy	230.2	224.1	242.6
Netherlands	247.3	243.9	258.0
Norway	760.8	724.1	729.1
Spain	380.8	370.1	354.7
United Kingdom	287.9	275.4	275.9
Yugoslavia	267.5	271.1	273.2
Other	476.5	450.6	454.6
Total	3 769.7	3 597.9	3 673.6
Africa			
Total	413.0	473.2	552.2
Asia			
Bahrain	177.3	174.8	178.2
India	267.9	266.5	257.1
Indonesia	199.0	216.8	218.8
Japan	286.7	226.5	140.2
U.A.E.	155.4	153.2	154.8
Other	98.2	114.6	117.3
Total	1 184.5	1 152.4	1 066.4
America			
Canada	1 222.0	1 282.3	1 355.2
United States	4 099.0	3 499.7	3 036.5
Brazil	455.0	549.4	757.4
Venezuela	386.0	403.1	423.0
Other	204.8	211.4	216.4
Total	6 366.8	5 945.9	5 788.5
Australasia			
Australia	754.8	851.7	875.0
New Zealand	242.9	243.5	236.2
Total	997.7	1 095.2	1 111.2
Total	**12 731.7**	**12 264.6**	**12 191.9**
Monthly Average	1 061.0	1 022.1	1 016.0
Socialist countries			
Romania	244.0	265.0	260.0
U.S.S.R.	2 300.0	2 300.0	2 350.0
Other European	209.7	212.5	214.4
China and Other Asia	435.0	435.0	490.0
Total	3 188.7	3 212.5	3 314.4
World Total	**15 920.4**	**15 477.1**	**15 506.3**

Source: World Bureau of Metal Statistics.

TABLE 8. WORLD CONSUMPTION OF ALUMINUM

	1984	1985	1986
		(000 tonnes)	
Europe			
Belgium	289.4	267.7	273.3
France	579.3	586.1	592.6
Germany, F.R.	1 151.6	1 160.9	1 186.7
Italy	448.0	470.0	510.0
Spain	191.4	195.2	231.7
United Kingdom	369.5	350.4	389.1
Yugoslavia	159.6	168.2	163.3
Other Europe	735.6	746.6	801.3
Total	3 924.4	3 945.1	4 148.0
Africa			
Total	191.4	212.6	208.8
Asia			
India	310.0	297.6	310.0
Japan	1 743.9	1 815.6	1 843.5
Other Asia	580.6	735.3	844.5
Total	2 634.5	2 848.5	2 998.0
America			
Canada	336.0	345.0	354.0
United States	4 457.0	4 282.0	4 268.0
Brazil	294.8	347.5	423.7
Other America	338.5	343.9	369.9
Total	5 426.3	5 318.4	5 415.6
Australasia			
Australia	265.4	283.5	293.6
Other Australasia	32.0	34.7	29.7
Total	297.4	318.2	323.3
Total	**12 474.0**	**12 642.8**	**13 093.7**
Monthly Average	1 039.5	1 053.6	1 091.1
Socialist countries			
German D.R.	218.0	230.0	227.0
Hungary	192.8	199.5	214.6
U.S.S.R.	1 800.0	1 850.0	1 885.6
China	630.0	700.0	750.0
Other	481.9	478.0	492.0
Total	3 322.7	3 457.5	3 568.6
World Total	**15 796.7**	**16 100.3**	**16 662.3**

Source: World Bureau of Metal Statistics.

Asbestos

A. IGNATOW

While factors such as mine closures, foreign exchange shortages in developing countries, uncertainty regarding future regulations, and adverse publicity associated with past exposure to asbestos dust in the workplace continue to hinder a recovery in Canada's asbestos production, the decline in shipments of asbestos (chrysotile) witnessed since 1979 appears to have bottomed out in 1987. Total shipments in 1987 were 665 000 t valued at $283 million compared to 662 381 t valued at $234 million in 1986, according to preliminary and revised figures.

Employment in the mining sector of this industry has decreased to about 2800 from over 8000 in 1979. Exports, generally accounting for about 95% of production, amounted to 477 000 t valued at $266 million during the first nine months of 1987, compared to 525 000 t valued at $292 million during the same period in 1986.

With the possible exception of the United States, the health controversy over asbestos calmed noticably during 1987 on the international scene. There were no significant regulatory developments and governments in general are increasingly moving towards the 'controlled use' approach in asbestos regulations, as embodied in the International Labour Organization's Convention on Safety in the Use of Asbestos adopted in 1986. Sweden ratified the Convention in 1987 and Canada is expected to ratify in early 1988. Once two countries ratify the Convention, it officially comes into force as an international instrument.

Canada takes the position that with enforcement of appropriate regulations to rigorously control exposure to asbestos dust the risks associated with chrysotile in mining, milling, product manufacture, transportation and handling can be reduced to acceptable levels.

CANADIAN DEVELOPMENTS

In June, the Quebec government announced it would provide the Jeffrey mine, owned by J M Asbestos Inc., with a loan guarantee of up to $42.5 million needed to complete a major expansion of the Jeffrey open pit. This expansion, reported to cost some $75 million over a two-year period, will allow the Jeffrey operation to maintain its current level of fibre production until about 1995.

At the end of the summer, Newfoundland's Cabinet approved the sale of 80% of the shares held by Transpacific Resources Inc. in Baie Verte Mines Inc. to an Australian company, Mineral Commodities Ltd., and its Canadian partners, First Toronto Capital Corporation.

The limited partnership, LAB Chrysotile Inc., which in 1986 consolidated the mining and milling operations at Thetford Mines-Black Lake of Lake Asbestos of Quebec, Ltd. (LAQ), Asbestos Corporation Limited and Bell Asbestos Mines, Ltd., announced at the end of October that the Bell mine would be closed for an indeterminate period as of March, 1988. Some 450 employees will be affected by this temporary closure.

Towards the end of 1986, the Directors of Cassiar Mining Corporation approved in principle a $38.8 million capital program for the first phase development of the McDame underground deposit on the company's property at Cassiar in northwest British Columbia. If financing for the development work can be arranged, the McDame orebody would replace the existing open pit mine when the pit reserves are exhausted in early 1991. Proven and probable reserves in the McDame deposit could take the operation through to the year 2000 at current production levels.

The Montreal-based Asbestos Institute, funded by contributions from the Governments of Canada and Quebec and most asbestos mining companies, continued its activities dedicated to promoting the safe use of asbestos in Canada and throughout the world. The Institute is paying increasing attention to assisting developing countries in the implementation of the 'controlled-use' approach through missions, seminars and training sessions focusing on dust control

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and work practices, airborne dust monitoring and medical surveillance.

In May, the Governments of Canada and Quebec and the asbestos industry announced the funding of a four year $11 million R&D program to be managed by the Asbestos Institute. These funds will be disbursed by the Institute for asbestos research into fundamental and applied problems, biomedical investigations, mining and processing research aimed at productivity improvements, and a major effort devoted to product development research.

Parallelling U.S. trends, reported consumption of asbestos in Canada dropped from about 27 000 t in 1984 to about 14 000 t in 1986. Related statistics in Table 5 are reported in three categories to protect company confidentiality.

HEALTH AND REGULATIONS

At the federal level, there were no regulatory developments specifically directed at asbestos in 1986. The new Environmental Protection Act, which lists asbestos as a designated substance as in the former Clean Air Act, received second reading in the House of Commons and is in hearings before a Parliamentary committee. Bill C30, legislation enabling the implementation of the Workplace Hazardous Materials Information System (WHMIS), received Royal Assent on June 30.

WHMIS is a joint federal/provincial/territorial standard for disclosing detailed information on hazardous substances used in Canadian workplaces. Asbestos is one of the thousands of substances to be covered by the regulations, which will mandate labelling, safety data sheets and worker training for all hazardous substances and products used in the workplace.

WORLD DEVELOPMENTS AND INTERNATIONAL REGULATIONS

Preliminary estimates indicate that world asbestos consumption in 1987 may exceed the 4.1 Mt recorded in 1985. An article in the "New Scientist" (January 29, 1987) commenting on a new survey by Roskill, a business information service, states that the Roskill report predicts "overall world asbestos consumption is expected to rise steadily for the foreseeable future." Increased use of asbestos for construction materials in the U.S.S.R., eastern Europe, China and much of Asia has now cancelled out the decline in North America and western Europe.

Major asbestos producers and their approximate share of production are: U.S.S.R., 58%; Canada, 18%; and Republic of South Africa, Zimbabwe and Brazil, each 4%. In terms of trade, however, Canada is the world's largest exporter accounting for about 40% of world imports of asbestos.

On the regulatory scene internationally, there were few significant developments impacting on asbestos. The 'asbestos in building' issue arising from the application of sprayed-on asbestos insulation for fire and sound proofing, continues to receive by far the major portion of adverse media and public attention today.

In April, lawyers representing the asbestos industry and lawyers for two labour groups presented oral arguments before the U.S. District of Columbia Appeals Court challenging the U.S. Occupational Safety and Health Administration's (OSHA) asbestos regulations issued in 1986. At year end, the Appeals Court had not issued its findings.

Regarding the U.S. Environmental Protection Agency's (EPA) proposed rulemaking, initiated in 1986, to ban certain asbestos-containing products and phase-out remaining asbestos uses, during 1987 EPA was redoing its background studies and regulatory impact analysis. In December, EPA issued a proposed rulemaking regarding disclosure of confidential business information related to these background studies.

On November 13, the Safe Building Alliance (SBA) filed a petition with the U.S. Court of Appeals for the DC Circuit to seek a review of the final rules issued in October by the United States EPA, pursuant to the Asbestos Hazard Emergency Response Act (AHERA) of 1986. In a motion accompanying the filing, SBA asked the court for an order expediting the proceeding. AHERA "asbestos-in-schools" rule requires that all public and private elementary and secondary schools inspect for friable and non-friable asbestos-containing materials, implement response actions and submit asbestos management plans to State authorities by October, 1988.

SBA, an association of leading U.S. building material companies who formerly manufactured asbestos containing materials, argues that expediting is appropriate because the EPA rules will, unless set aside, increase asbestos exposures in schools by encouraging unnecessary and inappropriate removal of asbestos-containing materials.

In the European Economic Community, the EEC Council Directive approved in 1983 on Protection in the Workplace 83/478/EEC, providing the basis on which member states were to adopt compliance laws, came into effect on January 1, 1987. The control limit for exposure to asbestos other than crocidolite, over an eight-hour sampling period, is 1 f/cm^3; for crocidolite the limit value is 0.5 f/cm^3.

A subsequent EEC directive on Marketing and Use 76/769/EEC, issued in 1985, limited a number of asbestos containing products as follows: toys; materials for spray-on application, except undercoatings for cars; products distributed in powder form (spackling compounds); items for smokers such as tobacco pipes and cigarette and cigar holders; catalytic filters and insulation devices for certain catalytic heaters and paints and varnishes. Work is still continuing on developing a fibre fixity test method for textiles as part of this directive.

In 1987, the EEC Council Directive on the Prevention of Environmental Pollution by Asbestos was adopted. The main features of this directive are to limit aqueous effluent discharges to less than 30 g of suspended matter per m^3 of aqueous effluent with no more than 0.7 m^3 of effluent discharged per tonne of asbestos-cement produced. All aqueous effluent arising from the manufacture of asbestos paper is to be recycled. Finally, member states are also required to ensure that when asbestos is used the concentration of asbestos in discharges into the air does not exceed the limit value of 0.1 mg/m^3.

With the adoption of the environmental directive, the EEC has completed its regulatory agenda for asbestos. Based on this regulatory approach, the EEC has implemented the 'controlled use' philosophy in its regulation of asbestos.

PRICES AND CONSUMPTION

Average real prices for asbestos, which had fallen dramatically since the 1980-81 period, improved marginally in 1987. Continued weak demand by the construction sector, which accounts for an estimated 75% of worldwide demand, along with the conversion to asbestos-free products in some industrialized countries, continues to generate an oversupply situation in western countries resulting in increased competition among producers. On the other hand, the market for shorter grade fibre has improved substantially and these grades are in short supply. Consequently, prices for the shorter grades are on the increase.

ALTERNATE FIBRES AND MATERIALS

While fibre substitution continues to make inroads into asbestos friction material products, the enthusiasm for substitution in asbestos-cement products has abated significantly. No 'miracle fibre' substitute has been found to replace asbestos in asbestos-cement products, and alternative fibres employed have generally been a mixture of natural and synthetic fibres. These substitute products are generally inferior to asbestos-cement on a cost/performance basis and prices for cellulose fibre, most often used as a replacement for asbestos, have been rising dramatically. Asbestos-cement accounts for about 75% of world asbestos consumption.

OUTLOOK

Weak demand, particularly for longer fibre grades, is expected to remain a problem for the medium term. However, previous mine closures in Canada have generated a shortfall of short fibre grades and prices for these grades were strong.

Canadian mine production during this decade is forecast to continue at current levels, in the range of 650 000 - 750 000 t of asbestos annually.

With the rationalization and partial consolidation of mining and milling operations in Quebec, available production capacity more closely matches demand for Canadian fibre. The rapid decline in production witnessed in the early 1980s has been stemmed and a slow turnaround in prices and demand can be expected.

Although the outlook remains uncertain in the United States, it appears that the direction of EPA's regulatory initiatives may be revised in light of more complete studies. With more comprehensive data, it may be that the EPA will move closer to a 'controlled-use' regulatory approach.

With the exception of the United States, the health issue that has plagued asbestos for so many years appears to be receding as more and more governments adopt the 'controlled-use' approach in asbestos regulations. The ILO's International Convention on Safety in the Use of Asbestos is considered the major turning point in this regulatory trend.

Certain markets, such as southeast Asia, appear poised for significant growth in asbestos consumption. However, while there are well-established needs for asbestos-cement products in construction and irrigation projects, in certain regions and particularly for developing countries, foreign exchange and debt problems will continue to hinder recovery and consequently, asbestos consumption.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
CANADA					
31200-1	Asbestos, in any form other than crude, and all manufactures thereof, n.o.p.	8.0	8.0	25	5.0
31205-1	Asbestos in any form other than crude, and all manufactures thereof, when made from crude asbestos of British Commonwealth origin, n.o.p.	free	8.0	25	free
31210-1	Asbestos, crude	free	free	25	free
31215-1	Asbestos, yarns, wholly or in part of asbestos, for use in manufacture of clutch facings and brake linings	5.5	5.5	25	3.5
31220-1	Asbestos woven fabric, wholly or in part of asbestos for use in manufacture of clutch facings and brake linings	8.0	8.0	30	5.0
31225-1	Asbestos felt, rubber impregnated for use as backing in manufacturing floor coverings	free	free	25	free
UNITED STATES					
518.11	Asbestos, not manufactured, asbestos, crudes, fibers and stucco, and asbestos sand and refuse containing not more than 15% by weight of foreign matter			free	
518.41	Asbestos cement pipes, tubes and fittings			0.15¢ per lb.	
518.44	Other asbestos cement articles			free	
518.21	Yarn, slivers, rovings, wick, rope, cord, cloth, tape and tubing, of asbestos, or of asbestos and any other spinnable fiber, with or without wire			free	
518.51	Asbestos articles n.o.p.			free	

Sources: The Customs Tariff, 1987, Revenue Canada, Customs and Excise. Tariff Schedules of the United States, Annotated (1987) USITC Publication 1910. U.S. Federal Register Vol. 44, No. 241.
n.o.p. Not otherwise provided for.

TABLE 1. CANADA, ASBESTOS PRODUCTION AND TRADE, 1985-87

	1985		1986		1987P	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Production (shipments)[1]						
By type						
Group 3, spinning	13 537	14 405	10 409	9 850	..	..
Group 4, shingle	233 969	150 676	194 511	107 748	..	..
Group 5, paper	150 223	63 729	127 172	51 004	..	..
Group 6, stucco	160 457	43 464	155 537	41 116	..	..
Group 7, refuse	192 004	26 322	174 752	24 335	..	..
Total	750 190	298 596	662 381	234 053	665 300	283 004
By province						
Quebec	615 719	223 622	540 733	178 036	510 000	214 213
British Columbia	89 350	56 715	78 348	39 663	95 300	47 791
Newfoundland	45 121	18 259	43 300	16 354	60 000	21 000
Total	750 190	298 596	662 381	234 053	665 300	283 004
Exports						
Crude (unspecified)					(Jan. - Sept.)	
Japan	521	164	-	-	-	-
United States	20	17	19	15	-	-
Italy	-	-	108	59	-	-
Argentina	20	15			-	-
Other	21	7	-	-	1 696	932
Total	582	203	127	74	1 696	932
Milled fibre (groups 3, 4 and 5)						
West Germany	23 399	22 309	31 681	26 202	17 888	13 550
Japan	33 745	25 632	34 751	25 032	19 286	14 374
United States	31 986	31 721	22 427	19 205	15 616	12 720
France	14 403	13 650	28 535	19 753	19 877	14 679
India	32 094	23 532	22 630	14 828	12 192	8 083
United Kingdom	15 150	15 886	15 428	13 706	8 034	6 586
Mexico	17 836	15 228	9 845	7 798	9 246	7 800
Italy	24 514	23 214	25 308	21 216	17 132	12 923
Australia	7 260	7 513	5 460	4 938	845	689
Malaysia	5 110	4 755	5 140	4 050	7 958	5 144
Thailand	21 487	14 580	16 542	10 592	15 109	9 054
Spain	10 463	9 095	13 814	8 265	8 983	6 818
Belgium-Luxembourg	6 928	6 766	6 463	5 460	6 166	5 210
Austria	9 117	8 313	10 339	8 215	8 910	6 343
Other countries	141 696	128 354	125 997	106 596	90 188	73 834
Total	395 127	350 548	374 360	295 856	257 430	197 807
Shorts (groups 6, and 7)						
United States	101 084	21 963	90 515	19 574	51 159	10 183
Japan	66 229	20 372	78 907	25 201	43 019	14 256
United Kingdom	12 429	4 601	9 876	2 992	5 221	1 422
West Germany	10 469	3 834	15 608	6 155	8 046	3 174
France	4 653	1 035	3 755	1 150	1 737	581
Mexico	9 334	2 552	7 570	1 818	8 350	2 201
India	14 085	5 050	15 847	6 456	11 658	4 886
Thailand	11 277	4 601	9 485	3 918	6 562	2 723
Taiwan	10 765	4 609	17 251	6 579	10 800	3 515
South Korea	18 393	5 303	24 091	7 504	17 322	6 002
Belgium-Luxembourg	6 397	2 134	6 520	2 079	5 187	1 583
Venezuela	1 850	434	4 575	691	6 416	1 460
Argentina	1 833	479	5 338	1 354	1 307	361
Nigeria	3 018	1 107	503	238	952	239
Switzerland	345	80	70	15	385	92
Other countries	54 133	17 614	50 997	16 911	40 204	14 142
Total	326 294	95 768	377 575	102 835	218 325	66 820
Grand total crude, milled fibres and shorts	722 003	446 519	715 395	398 765	477 451	265 559

TABLE 1. (cont'd)

	1985		1986		Jan.-Sept. 1987P	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Manufactured products						
Asbestos cloth, dryer felts, sheets						
United States		847		660		882
United Kingdom		482		491		348
Japan		70		-		3
Other countries		214		144		761
Total	..	1 163	..	1 295	..	1 994
Brake linings and clutch facings						
United States		7 943		2 614		1 812
Australia		55		-		-
Hong Kong		3		-		-
West Germany		59		-		-
France		45		-		-
Other countries		58		13		15
Total	..	8 163	..	2 627	..	1 827
Asbestos and asbestos cement building materials						
United States		7 420		6 592		3 088
United Kingdom		208		-		10
Australia		223		173		50
Singapore		116		-		-
Venezuela		152		143		-
Egyptian A.R.		-		90		-
Indonesia		117		191		-
Malaysia		24		-		-
Other countries		862		645		552
Total	..	9 117	..	7 834	..	3 700
Asbestos basic products, n.e.s.						
United States		2 531		1 356		1 425
West Germany		71		95		105
Mexico		96		22		-
Other countries		797		531		383
Total	..	3 495	..	2 004	..	1 913
Total exports, asbestos manufactured	..	22 388	..	13 760		9 434
Imports						
Asbestos, unmanufactured	374	635	325	664	183	333
Asbestos, manufactured						
Cloth, dryer felts, sheets, woven or felted		774		1 193		812
Packing		2 681		2 343		1 648
Brake linings		20 732		20 676		16 210
Clutch facings		2 109		2 057		1 641
Asbestos-cement shingles and siding		34		18		6
Asbestos-cement board and sheets		692		298		119
Asbestos building materials, n.e.s.		1 071		806		855
Asbestos basic products, n.e.s.		1 257		1 114		2 175
Total asbestos, manufactured	..	29 350	..	28 505	..	23 466
Total asbestos, unmanufactured and manufactured	..	29 985	..	29 169	..	23 799

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Value of containers not included.
P Preliminary; - Nil; n.e.s. Not elsewhere specified; .. Not available.

TABLE 2. CANADIAN ASBESTOS PRODUCERS, 1986

Producers	Mine Location	Normal Mill Capacity ore/day	 fibre/year	Remarks
		(tonnes)		
Baie Verte Mines Inc.	Baie Verte, Nfld.	6 600	80 000	Open-pit.
LAB Chrysotile Inc.[1]				Partnership owned 55% LAQ and 45% Société nationale de l'amiante (SNA)
- Lake Asbestos of Quebec, Ltd. (LAQ)	Black Lake, Que.	9 000	160 000	Open-pit. A joint venture with ASARCO Incorporated and Campbell Resources Inc.
- Asbestos Corporation Limited				(SNA) Quebec Crown corporation.
British Canadian mine	Black Lake, Que.	7 000	70 000	Open-pit.
King mine	Thetford Mines, Que.			An underground operation - closed in October.
Bell Asbestos Mines, Ltd.	Thetford Mines, Que.	2 700	70 000	(SNA) Quebec Crown corporation. Underground.
J M Asbestos Inc. Jeffrey mine	Asbestos, Que.	15 000	300 000	Open-pit (effective capacity reduced by one-half in 1982).
Cassiar Mining Corporation	Cassiar, B.C.	5 000	100 000	Open-pit.
Total of six producers at year-end			780 000	

[1] A partnership involving three operating companies.

TABLE 3. CANADA, ASBESTOS PRODUCTION AND EXPORTS, 1981-87

	Crude	Milled	Shorts	Total
		(tonnes)		
Production[1]				
1981	10	567 288	554 547	1 121 845
1982	-	394 554	439 695	834 249
1983	-	448 953	408 551	857 504
1984	-	442 503[r]	394 151[r]	836 654
1985	-	397 729	352 461	750 190
1986		332 092	330 289	662 381
1987P	..	..	..	665 300
Exports				
1981	10	519 777	542 402	1 062 189
1982	555	454 440	425 701	880 696
1983	931	384 068	368 912	753 911
1984	167	430 391	366 206	795 853
1985	582	395 127	326 294	722 003
1986	127	374 360	377 575	752 062
1987[2]	1 696	257 430	218 325	477 451

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Producers' shipments. [2] Jan.-Sept.

P Preliminary; - Nil; .. Not available; [r] Revised.

TABLE 4. WORLD ASBESTOS PRODUCTION, 1986

Country	Tonnes[e]
U.S.S.R.	2 500 000
Canada[1]	662 381
Zimbabwe	174 000
Brazil	200 000
Rep. of South Africa	140 000
China	150 000
Italy[1]	115 208
United States[1]	51 437
Greece	48 000
Turkey	15 000
Swaziland	25 000
Cyprus	16 000
Colombia	13 000
Yugoslavia	7 000
Korea	5 000
Japan	4 000
India	2 000
Argentina	1 100
Bulgaria	500
	4 129 626

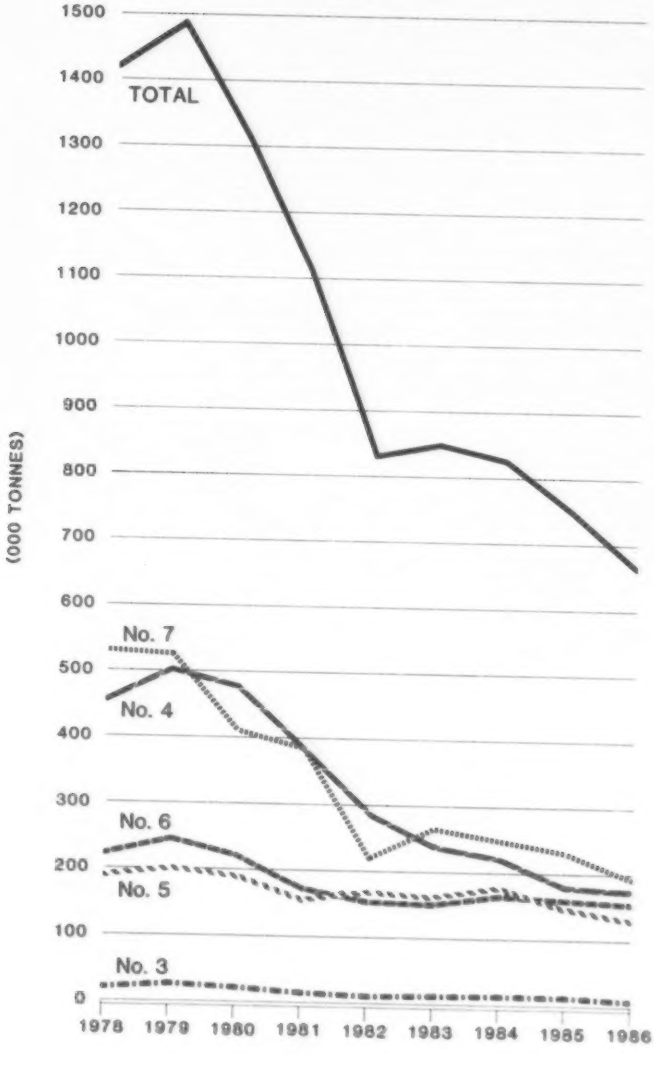
Sources: U.S. Bureau of Mines and Energy, Mines and Resources Canada.

[1] Reported figure; [e] Estimated.

TABLE 5. CANADIAN ASBESTOS CONSUMPTION, 1984-86

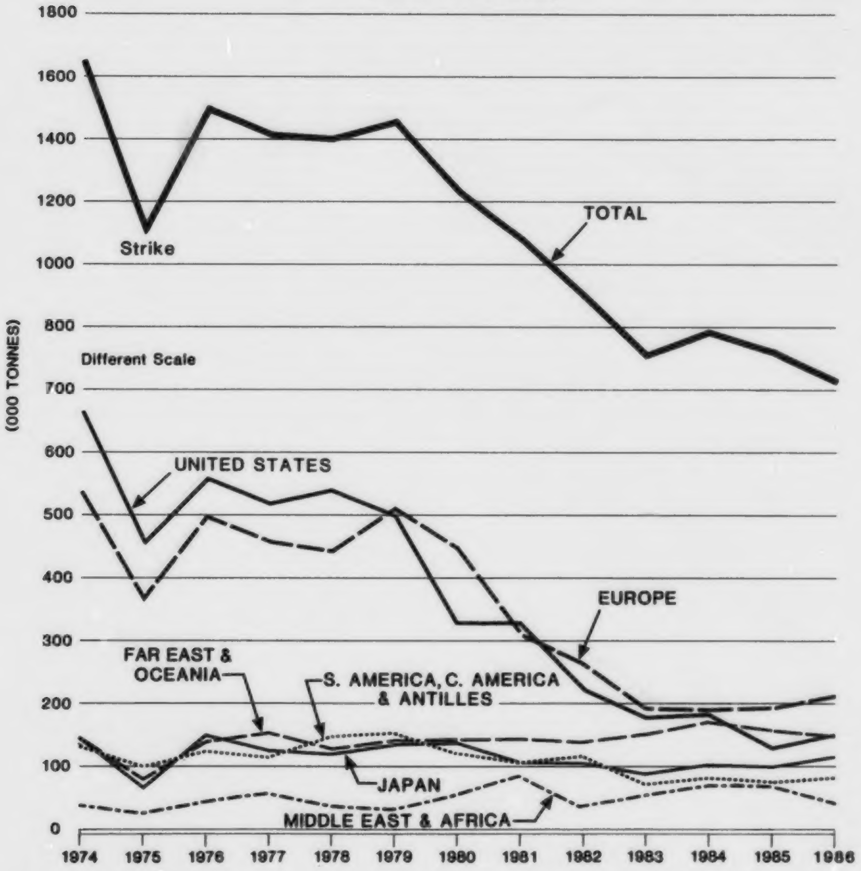
	1984		1985		1986	
	(tonnes)	(%)	(tonnes)	(%)	(tonnes)	(%)
Paper; textiles, a/c sheet; a/c pipe; insulation; roofing	11 792	44	7 062	35	7 165	52
Flooring products, plastics; coatings and compounds	8 898	33	6 607	33	3 240	24
Friction products; packing and gaskets	6 123	23	6 309	32	3 273	24
Total	26 813	100	19 978	100	13 678	100

CANADIAN ASBESTOS SHIPMENTS 1978 - 86

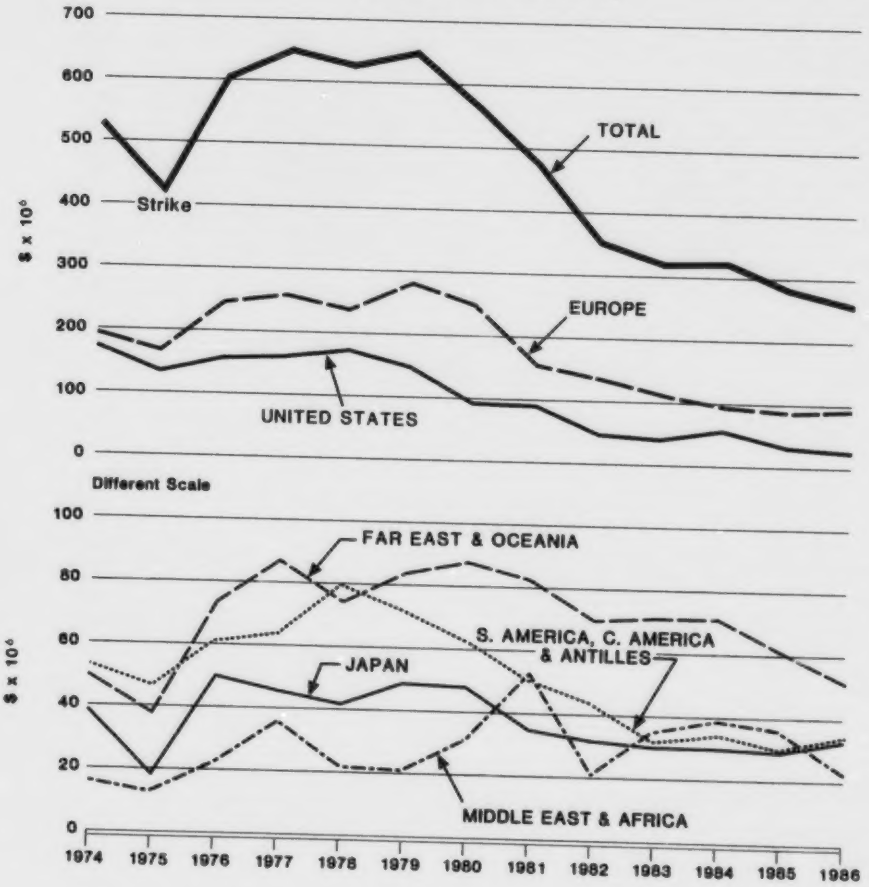


CANADIAN EXPORTS OF ASBESTOS (ALL GROUPS) BY COUNTRY OR REGION (1974-86)

(000 Tonnes)



CANADIAN EXPORTS OF ASBESTOS (ALL GROUPS) BY COUNTRY OR REGION (1974-86) (Constant 1979 $)



Barite and Celestite

D.J. SHAW AND M.A. BOUCHER

BARITE

SUMMARY

Barite ($BaSO_4$-barium sulphate) is the most common and abundant ore mineral of barium. Alternate sources of barium include witherite ($BaCO_3$-barium carbonate) and sandbornite ($BaSi_2O_5$-barium silicate). Pure barite contains 58.8% barium and 41.2% sulphate and is valued for its high specific gravity, low abrasiveness, chemical stability and lack of magnetic and toxic effects.

The mineral's dominant use is as a weighting agent in oil and gas drilling muds required to counteract high pressures confined by the substrata. Secondary market applications include fillers and extenders in paint, rubber and paper manufacture, and as a flux agent in the production of glass.

The major world producers of barite are: China, U.S.S.R., United States, Morocco, Mexico and India. In recent years, China has become very important in world trade and is the leading foreign supplier of barite to the United States.

Apparent Canadian consumption of barite in 1987 was down 14.9% to 38 949 t, the bulk of this decline being due to depressed drilling fluid demand. The impact of this decline was mainly on imports as first nine months statistics of 1987 show a 63% decline from the same period in 1986. In 1987, domestic shipments of 40 550 t were virtually unchanged from 1986, although value decreased 7.8% to $3 886 000.

The short-term outlook for world barite demand is one of modest growth. Expectations of recovery in world oil prices and oil and gas exploration in the upcoming year should alleviate depressed demand conditions for barite. Filler and extender markets should keep pace with modest automotive and construction sectoral growth. However, expectations of continued North American industry consolidation, by way of mine and plant closings, and intra-industry mergers, persist.

MINERALOGY AND GEOLOGY

Barite ($BaSO_4$-barium sulphate), also called baryte, tiff, cawk or heavy spar, is the most common and abundant ore mineral of barium. Alternate sources of barium such as witherite ($BaCO_3$-barium carbonate) and sandbornite ($BaSi_2O_5$-barium silicate) do not commonly occur in commercial concentrations. The potential resources of barium from these latter two sources is unknown, but is generally thought to constitute only a minor portion of the world's resources.

Barite occurs in many geological environments including sedimentary, igneous and metamorphic rocks; and in sufficient concentrations as to permit its commercial recovery either as a primary product or as a coproduct or by-product. The mineral occurs principally in bedded, vein and residual deposits, as well as a gangue mineral in association with metallic sulphide deposits. In terms of world barite resources, bedded deposits are the most important. They generally occur as stratiform beds, lenses, or discontinuous horizons that are conformable with the enclosing rocks. Vein deposits are generally hydrothermal in origin and are smaller than bedded deposits. Residual deposits of barite are formed in a clay-bearing or clay residium that results from surficial weathering. Commonly associated minerals include quartz, chert, jasperoid, calcite, dolomite, siderite, celestite, fluorite and sulphide minerals such as pyrite, galena and sphalerite.

Pure barite contains 58.8% barium and 41.2% sulphate. Its specific gravity is 4.5 but this value can be significantly lower in natural barite with inclusions of other associated minerals. In most commercial deposits barite occurs as irregular masses, concretions, nodules and rosette-like aggregates

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and in finely crystalline massive to laminated beds. Shades of white to dark grey and black, depending on impurities, are common; and the soft crystalline material has a Moh's scale hardness between 2.5 and 3.5. Barite is also relatively insoluble in water and acid, and thus can be used as a chemically inert material.

CANADIAN DEVELOPMENTS

Consumption and Trade

Apparent consumption of barite in 1987, based on preliminary statistics for the year, was down 14.9% to 38 949 t. This latter total is 50% lower than barite consumption in 1985. Reported consumption, whose coverage is not complete, indicates that the bulk of the decrease in consumption was due to depressed drilling fluid demand.

For the first nine months of 1987 barite trade between Canada and the rest of the world showed a surplus for the first time. This came about as imports of barite fell 63.1% from the same nine month period in 1986 to 3 273 t. Exports, on the other hand, grew 21.7% over the year, when comparing first nine months statistics only. More remarkedly, the value of these exports was $1 840 000, two and half times the first nine month level of 1986.

Production and Deposits

Barite was produced in 1987 from operations located in British Columbia, Ontario and Nova Scotia. Total barite shipments for the year were 40 550 t, virtually unchanged from 1986. The value of these shipments was $3 886 000, down 7.8% from the previous year.

Mountain Minerals Co. Ltd. of Lethbridge, Alberta has in the past mined crude barite from two underground mines, Brisco and Parsons, and recovered barite from tailings at Mineral King. All three are located in southeast British Columbia, however, only the Brisco mine was active in 1987. The crude barite is shipped to the company's grinding plant in Lethbridge, where production capacity is 140 000 t/y. Mountain Mineral's products are primarily destined to well drilling markets located in Alberta; however, recent product diversification to include filler and extender markets in Ontario has been successful.

NL Chem Canada Inc., a subsidiary of N L Industries, Inc., has in the past recovered barite from tailings at the Silver Giant mine near Spillimacheen, B.C. This material is fed in slurry form to separation tables and the dewatered concentrate is further processed at its mill in Onoway, Alberta. Feed to this 25 000 t/y mill is also obtained from Nevada, U.S.A. and tailings at the Buchans mine in Newfoundland. However, in 1987 there was no barite production from the Buchans mine.

M-I Drilling Fluids Canada, Inc.'s Fireside, B.C. mine and Watson Lake, Yukon plant were inactive in 1987. Extender Minerals of Canada Limited mines barite near Matachewan, Ontario. Production of the high-quality, dry-ground product by open-pit mining methods is used for filler and extender purposes, primarily in paint and plastics applications.

In Nova Scotia, Nystone Chemicals Ltd. produced pharmaceutical-grade barite from its deposit 2 km northeast of Brookfield. Almost all of the company's shipments are destined for export to its parent company's plant in New York state. Diversification to supply drilling-grade barite may be possible under favourable conditions.

WORLD DEVELOPMENTS

In 1986, world production of barite declined 29.5% to 4.3 Mt in response to a major world downturn in oil and gas exploration. However, barite consumed in other applications, such as fillers and extenders, glass, barium chemicals and ceramics remained fairly stable over the past year.

World production of barite is dominated by six large producer countries. China, the U.S.S.R., Morocco, the United States, Mexico and India accounted for 59.1% of world production in 1986.

In the **United States** domestic and imported shipments of barite declined 47.3% to 1 016 000 t in 1986. The severe fall in drilling fluid demand was prompted by a 50% drop in the number of operating oil and gas rigs in the United States which, in turn, was prompted by sharply declining world oil prices. In 1986, barite consumed by the well drilling mud industry accounted for 65% of domestic sales, down from its long-term average of 90%.

In 1986, U.S. barite production declined 49% to 342 918 t, valued at $16 million. The six leading producers accounted for 90% of this production. Production originated from six states, with Nevada accounting for 69% of the total.

The last couple of years have witnessed several mergers and acquisitions in the drilling fluids industry. Most notably, Dresser Industries, Inc. and its Magcobar division, excluding lead-mining operations, merged with IMCO Services Division of Halliburton Company to form M-I Drilling Fluids Canada, Inc. Milchem, Inc., a subsidiary of Baker International Corp., and Newpark Resources Inc., a subsidiary of Eisenmann Chemical Co., formed a new partnership named Milpark. Dowell Schlumberger Inc. sold their Amelia, La., plant to DL Mud Co. who, in turn, leased the plant to Hughes Drilling Fluids.

Mexico has for many years been a major barite producer, and in 1982 became self-sufficient in barite generating a small surplus for export. Mexican barite production in 1986 is estimated to have declined 35% to 317 519 t. The year 1985 saw record production of 489 883 t. The country's production capacity is estimated at approximately 1.17 Mt/y, located mainly in the states of Nuevo Leon, Coahuila, Sonora and Cuerrero. Practically all domestic production is sold to the state-owned petroleum producer Petróleos Mexicanos (Pemex).

Moroccan barite production is estimated to have declined 15% to 362 876 t in 1986. There are seven Moroccan barite producers and Cie Marocaine de Barytes (COMABAR) dominates within excess of 60% of the country's production capacity. Most of the country's output is of drilling fluid grade, and is exported to the United States (50%) and western Europe (25%).

USES AND SPECIFICATIONS

The major use of barium is in the form of barite as a weighting agent in well drilling muds. The muds are mixtures of water, clay, barite and other ingredients of different proportions that vary according to local reservoir conditions. The mud serves several functions such as lubricating and cooling the drill bit, carrying cuttings to the surface, sealing the walls of the hole and confining high gas and oil pressures. Principal specifications for barite in well-drilling usually requires a minimum specific gravity of 4.2, a particle size of 90-95% minus 325 mesh, 92-94% $BaSO_4$ and a maximum of 250 ppm soluble alkaline earths, as calcium.

Ground barite, both unbleached and bleached by sulphuric acid, is used as an extender pigment in paint and as a filler in rubber, plastic and paper. Barite's high density, low oil absorption, chemical inertness and easy wettability by oils have promoted its use in industrial metal and automotive primers. The smooth crystalline surface of barite particles prevents agglomeration, thus enhancing the dispersibility in liquid systems. Barite also does not absorb or scatter incident light which is necessary for use as a pigment. In filler applications, barite's specific gravity and its relative low cost is the main reason for its use. Specifications for barite used in the paint industry call for 95% $BaSO_4$, particle size of at least minus 200 mesh and a high degree of whiteness or light reflectance.

The glass industry uses barite to increase the workability of glass, to act as a flux, assist decolouration and increase the brilliance or lustre of the product. Specifications call for a minimum of 96 to 98% $BaSO_4$, a particle size range of 40 to 140 mesh, no more than 0.1 to 0.2% Fe_2O_3 and only a trace of TiO_2.

Chemical uses include metal hardening, fabric treatment, water purification, magnesium metal production, and brick manufacture (barium carbonate); munitions (barium nitrate); electric furnace ferrous metallurgy (barium oxide); ceramics, oils and sugar refining (barium hydroxide); and electronics (barium titanite). Chemical-grade barite must have a minimum 95% $BaSO_4$ maximum 0.5 to 1.0 Fe_2O_3, maximum 1.0% $SrSO_4$, and fluorine (trace).

PRICES

Excess world supplies and low ocean-freight rates continued to depress published prices for all drilling mud grade barite. Notably, low-cost crude barite from China continued to affect western world prices downward. List prices in the range of US$110-150 for barite used in smaller quantities in chemical and filler/extender markets remained the same, although discounting from these list prices was practiced throughout the industry.

United States prices of barite as reported in Engineering and Mining Journal[1] of December 1987.

	$ per short ton
Unground	
Chemical and glass grade:	
Hand picked, 95% $BaSO_4$, not over 1% Fe	90.00
Magnetic or flotation, 96-98% $BaSO_4$, not over 0.5% Fe	116.00
Imported drilling mud grade, specific gravity 4.20-4.30, c.i.f. Gulf ports	26.00-39.00
Ground	
Water ground, 95% $BaSO_4$ 325 mesh, 50-lb bags	70.00-165.00
Dry ground, drilling mud grade, 83-93% $BaSO_4$, 3-12% Fe, specific gravity 4.20-4.30	40.00-55.00
Imported	
Specific gravity 4.20-4.30	40.00-55.00

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[1] Published by McGraw-Hill.

c.i.f. Cost, insurance and freight.

OUTLOOK

Since the rapid decline of world oil prices in January 1986 the North American well drilling industry has been in recession. Oil and gas wells completed in the United States for the first half of 1987 was down 29% from the same period in 1986. The year 1986 saw the fewest wells completed in the United States in over a decade. In Canada, however, oil drilling rebounded slightly as producers took advantage of a five-year royalty holiday on new wells drilled before November 1987 and a federal assistance program that covers one-third of drilling costs up to $3 million. Slow and erratic growth in barite consumption is expected in the short term as forecasts of sluggish oil markets persist.

The demand for barite for filler and extender markets will show only modest growth of 2.5 to 3.5%. This forecast is predicated on expectations of modest growth in automotive and construction sectors.

Pharmaceutical grade barium sulphate demand, used as contrast media in radiological applications, is expected to decline as technological advances in medicine which are seeing the replacement of conventional X-ray equipment by advanced CAT scanning is occurring.

CELESTITE (STRONTIUM)

SUMMARY

There has been no Canadian production of celestite ($SrSO_4$) since 1976 when Kaiser Celestite Mining Limited, a subsidiary of Kaiser Aluminum & Chemical Canada Investment Limited, closed its mining operation at Loch Lomond, Nova Scotia and its strontium products plant at Point Edward, Nova Scotia. In 1985, Timminco Limited, was issued a special license on 19 claims containing the McCrae celestite deposit at Enon, Cape Breton County, Nova Scotia. Since then Timminco has retained the services of ACA Howe International Limited to evaluate and determine the in place reserves of the deposit. So far reserves are reported to be 400 000 t grading 55.7% celestite. More drilling is planned for 1988.

Assuming a 10% dilution factor in mining, and recoveries of 90% and 84% in the concentrator and the carbonate plant, respectively, the in place reserves could produce about 120 000 t of prime strontium carbonate.

Timminco plans to produce about 10 000 t/y of strontium carbonate, equivalent to 35 000 t/y of celestite starting in late 1988 or early 1989. The carbonate would be shipped to Westmeath, near Pembroke, Ontario where it would be transformed into strontium metal using calciners, gas fired vacuum furnaces and reducing agents.

NORTH AMERICAN SCENE

North American consumers continue to depend totally on imports of strontium minerals. The strontium mining industry in the United States has been dormant since 1969, and Mexico is the major supplier of celestite to the U.S. market.

In the United States, imports of celestite in recent years were about 45 000 t/y while imports of chemicals average 4 000 t/y.

USES

Celestite is used to produce commercial strontium compounds, principally strontium carbonate and to a much lesser extent strontium nitrate. Strontium carbonate is primarily used in glass faceplates for colour television picture tubes, where it improves the absorption of X-rays emitted by the high voltage tubes. Other uses include: pyrotechnics (a major use for strontium nitrate produced by acidification of $SrCO_3$); ferrite ceramic permanent magnets for small electric motors; and in electrolytic zinc refining. Strontium metal is a minor component in lead-strontium alloys. The metal is also used to modify the eutectic silicon in hypo- and hyper-eutectic aluminum/silicon casting alloys from coarse platelets to fine fibre form. This improves in-cast ductility and enhances feeding in the mould.

PRICES

United States prices of celestite according to Chemical Marketing Reporter, December 1986 and 1987

	$ per short ton	
	1986	1987
Strontium carbonate glass grade, bags, truckload, works	745.00	745.00
	$ per 100 pounds	
Strontium nitrate, bags, carlot, works	51.50	51.50

TABLE 1. CANADA, BARITE PRODUCTION AND TRADE, 1985-87 AND CONSUMPTION, 1983-86

	1985		1986		1987P	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Production (mine shipments)	71 049	5 503	36 888	4 635	40 550	3 886
					(Jan.-Sept.)	
Imports						
United States	7 033	820	10 030	1 032	2 581	372
Ireland	8 011	381	-	-	-	-
Netherlands	489	170	489	185	692	190
Morocco	11 020	808	-	-	-	-
Other	34	13	7	1	-	-
Total	26 587	2 192	10 519	1 218	3 273	562
Exports						
Madagascar	-	-	-	-	200	50
West Germany	-	-	..	1	-	-
United States	1 679	479	5 072	982	4 674	1 790
Total	1 679	479	5 072	983	4 874	1 840
Apparent Consumption	95 957		45 782		38 949	
		1983	1984	1985	1986P	
Reported Consumption[1]						
Well drilling[e]		60 000	64 000	51 000	15 000	
Paint and varnish		1 484	1 449	1 526	1 298	
Other[2]		4 200	6 119	6 758	6 403	
Total[e]		65 684	71 568	50 294	22 701	

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Available data reported by consumers with estimates by Energy, Mines and Resources Canada. Does not include inventory adjustments. [2] Other includes plastics, bearings and brake linings, foundries, chemicals, explosives, glass and glass products, etc.
P Preliminary; [e] Estimated; - Nil; .. Not available.

TABLE 2. CANADA, BARITE PRODUCTION TRADE AND APPARENT CONSUMPTION, 1983-87

	Production[1]	Imports	Exports	Apparent Consumption
		(tonnes)		
1983	45 465	29 952	795	74 622
1984	64 197	17 688	1 248	80 637
1985	71 049	26 587	1 679	95 957
1986	40 335	10 519	5 072	45 782
1987P	40 550	3 273	4 874	39 949

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Mine shipments.

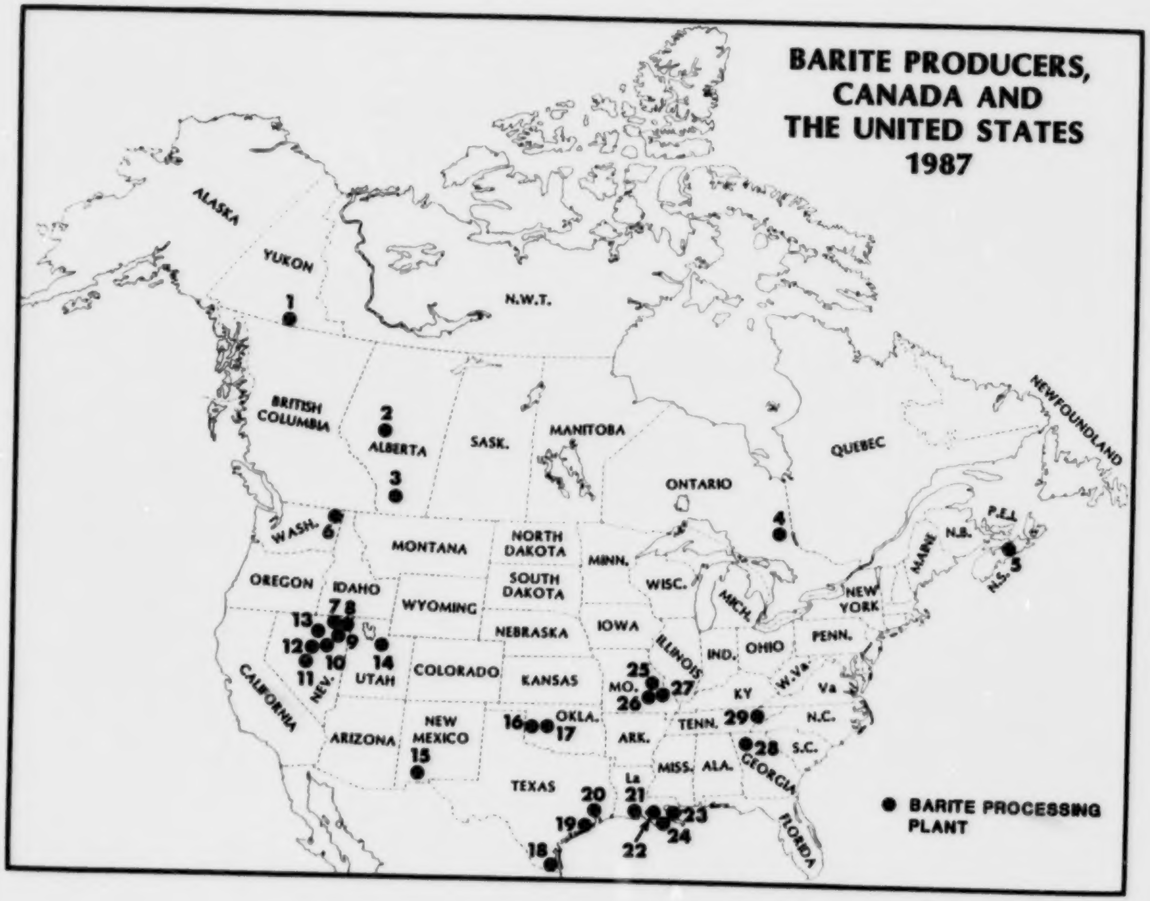
P Preliminary.

TABLE 3. WORLD BARITE PRODUCTION, 1985 and 1986

Country	1985	1986
	(tonnes)	
China[e]	998	816
United States	670	343
India	608	272
U.S.S.R.[e]	540	408
Morocco	425	363
Mexico	490	318
Ireland	220	91
Thailand	172	136
Germany, Federal Republic of	170	136
Peru	163	136
France	150	136
Italy	100	82
Canada	45	36
Yugoslavia	36	36
Other Market Economy Countries	1 017	816
Other Centrally Planned Economies	248	181
	6 051	4 306

Sources: U.S. Bureau of Mines; Energy, Mines and Resources Canada.

[e] Estimated.



BARITE PRODUCERS, CANADA AND THE UNITED STATES 1987

ALASKA
YUKON
N.W.T.
BRITISH COLUMBIA
ALBERTA
SASK.
MANITOBA
ONTARIO
QUEBEC
NEWFOUNDLAND
P.E.I.
N.B.
N.S.
MAINE
NEW YORK
PENN.
OHIO
IND.
MICH.
WISC.
MINN.
IOWA
ILLINOIS
MO.
KY
W.Va.
Va
N.C.
S.C.
TENN.
ARK.
MISS.
ALA.
GEORGIA
FLORIDA
La
TEXAS
OKLA.
KANSAS
NEBRASKA
SOUTH DAKOTA
NORTH DAKOTA
MONTANA
WYOMING
COLORADO
NEW MEXICO
ARIZONA
UTAH
NEV.
IDAHO
OREGON
WASH.
CALIFORNIA
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● BARITE PROCESSING PLANT

Company	Parent Corporation	Plant Capacity (t/y)	Market Applications
1. M-I Drilling Fluids Canada, Inc.	-	n.a.	Drilling fluids
2. NL Chem Canada, Inc.	N L Industries, Inc.	25 000	Drilling fluids
3. Mountain Minerals Co. Ltd.	-	140 000	Drilling fluids, fillers and extenders
4. Extender Minerals of Canada Limited	-	13 500	Fillers and extenders
5. Nystone Chemicals Ltd.		15 000	Pharmaceuticals
6. C-E Minerals, Inc.	Combustion Engineering, Inc.	40 000	Drilling fluids
7. Chromalloy American Inc.	-	200 000	Drilling fluids
8. All Minerals	-	200 000	Drilling fluids
9. Circle A Mining Co.	-	n.a.	Drilling fluids
10. Milchem/Milpark Incorporated	Baker Hughes Incorporated & Eisenmann Chemical Co.	180 000	Drilling fluids
11. M-I Drilling Fluids Canada, Inc.	-	225 000	Drilling fluids
12. M-I Drilling Fluids Canada, Inc.	-	200 000	Drilling fluids
13. NL Chem Canada, Inc.	N L Industries, Inc.	270 000	Drilling fluids
14. Custom Milling Company	-	50 000	Drilling fluids
15. Barite Company of America	-	150 000	Drilling fluids
16. Old Soldier Mining Company	-	110 000	Drilling fluids
17. Milchem/Milpark Incorporated	Baker Hughes Incorporated & Eisenmann Chemical Co.	160 000	Drilling fluids
18. M-I Drilling Fluids Canada, Inc.	-	200 000	Drilling fluids
19. a) Milchem/Milpark Incorporated	Baker Hughes Incorporated & Eisenmann Chemical Co.	130 000	Drilling fluids
b) M-I Drilling Fluids Canada, Inc.		n.a.	Drilling fluids
20. a) Hughes Drilling Fluids	W.R. Grace and Company	n.a.	Drilling fluids
b) Chromalloy American Inc.	-	130 000	Drilling fluids
c) M-I Drilling Fluids Canada, Inc.	-	400 000	Drilling fluids
21. Old Soldier Mining Company	-	(1)	Drilling fluids
22. DL Mud Co.	-	250 000	Drilling fluids
23. a) Milchem/Milpark Incorporated	Baker Hughes Incorporated & Eisenmann Chemical Co.	260 000	Drilling fluids
b) M-I Drilling Fluids Canada, Inc.	-	n.a.	Drilling fluids
24. a) Hughes Drilling Fluids	W.R. Grace and Company	n.a.	Drilling fluids
b) Chromalloy American Inc.	-	240 000	Drilling fluids
c) M-I Drilling Fluids Canada, Inc.	-	200 000	Drilling fluids
25. DeSoto Mining Company	Galveston-Houston Company	50 000	Drilling fluids, chemicals
26. N L Industries, Inc.	-	n.a.	Chemicals
27. M-I Drilling Fluids Canada, Inc.	-	75 000	Drilling fluids
28. a) Paga Mining Co.	Thompson Weimann & Company	25 000	Fillers and pigments
b) New Riverside Ochre Company	Chemical Products Corp.	28 000	Chemicals
29. CR Wood Company Inc.	-	6 000	Fillers and pigments

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(1) Combined plant production at Old Soldier Mining Company's two locations is 110 000 t/y.
n.a. Not available; - Nil.

Bentonite

D. SHAW

SUMMARY

Bentonite is a clay of varied chemical composition, consisting primarily of the mineral montmorillonite. Bentonite, with sodium as the dominant exchangeable ion, can swell 10 times its original volume and possesses a high dry-bonding strength. Sodium bentonites primarily serve as a suspension aid in water-based muds for well drilling; as a binder in iron ore pelletizing, in moulding sands for ferrous foundries and animal feed. Bentonite, with calcium as the dominant exchangeable ion, exhibits more pronounced adsorptive characteristics. Calcium bentonite is used as a binder in moulding sands for ferrous foundries and feed stock pellets; as a carrier and diluent for pesticides; and as a cleaning powder for animals.

Reported Canadian consumption in 1986 was down 13.7% to 237 890 t. Practically all industry consumers used less bentonite in 1986, in particular the well drilling industry where consumption fell 47.4% from the previous year.

Canadian shipments of bentonite rose 22.7% in 1987 to 88 347 t. The value of these shipments was $1 151 000. In Canada, sodium bentonite is produced in Saskatchewan and Alberta, while calcium bentonite is produced in Manitoba.

In the immediate short-term a moderate rebound from depressed North American markets for bentonite is expected. Oil and gas exploration is expected to recover only moderately in 1988. The ferrous foundry industry is expected to show modest growth over the longer term, however, iron ore pelletizing will continue to decline. Substitute binders in iron ore pellet making are now emerging. Should this latter trend continue, the 1990s may be a period of phasing out bentonite consumption in iron ore pelletizing altogether.

MINERALOGY AND GEOLOGY

Bentonite is a clay of varied chemical composition consisting primarily of the mineral montmorillonite, a member of the smectite group of clay minerals. Essentially, montmorillonite is a hydrated aluminum silicate with a theoretical formula as a group of $(OH)_4Si_8Al_4O_{20}nH_2O$, but owing to substitution in the crystal structure this compound does not exist in nature. The mineral comprises fine grained micaceous-like sheets with weakly-attached cations of calcium, sodium, magnesium and potassium. Active clay nomenclature classifies bentonite in the sodium and calcium montmorillonite smectitic group.

Bentonite may originate from smectitic clays formed from volcanic ash, tuff or glass, other igneous rocks, or from rock of sedimentary or uncertain origin. The deposits occur in flat lying beds having various chemical compositions and mineral impurities. Natural clay may be creamy white, grey, blue, green or brown; and, in places, beds of distinctly different colours are adjacent. Fresh moist surfaces are waxy in appearance; on drying, the colour lightens and the clay has a distinctive cracked or crumbly texture.

Bentonite, with sodium as the dominant or abundant exchangeable ion, can swell 10 times its original dry volume, and when added to water, gel-like masses result. Sodium bentonite also possesses a high dry-bonding strength, especially at high temperatures, a feature important in the pelletizing of iron ores and in the manufacture of some ceramic products.

Montmorillonite clays have ion-exchange properties and, by adsorption, absorption and chemical activity, bentonite can collect many types of inorganic and organic compounds, sometimes selectively. In general,

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the non-swelling or calcium bentonites exhibit the more pronounced adsorptive characteristics. While naturally-occurring clays may exhibit adsorptive or bleaching properties, their efficiencies are commonly improved by acid leaching or, as the process is generally termed, activation.

Another clay, "fuller's earth", also contains mainly smectitic group clay minerals and is very similar to non-swelling bentonite. These clays are non-plastic, usually high in magnesia and have natural bleaching and absorbent properties allowing their use for decolourizing and purifying.

CANADIAN DEVELOPMENTS

Consumption and Trade

Reported Canadian consumption of bentonite in 1986 was down 13.7% to 237 890 t. Excluding the refractories industry, all major consuming industries reduced their demand for bentonite in 1986. In particular, bentonite consumed by the well drilling industry was down 47.4% from 1985. The distribution of reported consumption by market application in 1986 was: iron ore pelletizing, 60.7%; foundry binders, 22.6%; well drilling, 14.1%; and others 2.6%.

For the first nine months of 1987 Canadian imports of bentonite were down 5.4% from the same nine month period of 1986 to 203 776 t, with an associated value of $9 237 000. Meanwhile, imports of activated clays and fuller's earth for the first nine months of 1987 rose 13.9 and 72.7% from the same period in 1986 to 11 065 and 6 680 t, respectively.

Production and Occurences

In 1987, Canadian bentonite production was 88 347 t, up 22.7% from 1986. The value of these shipments was $1 151 000, up 26.6% from 1986. In Canada, bentonite is produced in Manitoba, Saskatchewan and Alberta. Known Canadian bentonite occurrences are confined to Cretaceous and Tertiary rocks at many localities in Manitoba, Saskatchewan, Alberta and British Columbia. Although clay beds occur in rocks older than Cretaceous in Canada, none of these have been identified as bentonite.

Pembina Mountain Clays Incorporated, a subsidiary of Harshaw/Filtrol Partnership, mines non-swelling bentonite from the Upper Cretaceous Vermillion River Formation, 30 km northwest of Morden, Manitoba, which is 130 km southwest of Winnipeg. Some bentonite is dried and pulverized in a plant at Morden, but the bulk of production is railed from Morden to the company's activation plant at Winnipeg, where it is leached, washed, filtered, dried, pulverized and bagged. The main use of this product is for decolourizing and purifying mineral and vegetable oils, animal fats and tallows. Highly sorptive properties also make this bentonite suitable for pet litters and floor sweeping compounds.

In Saskatchewan, Avonlea Mineral Industries Ltd. operates a processing plant in Wilcox, approximately 30 km south of Regina. Raw material is transported a distance of approximately 20 km to the 60 000 t/y plant. Major uses of the final product are for well-drilling muds by the oil industry, as a binder in foundry sands, for civil engineering applications such as reservoir sealing, and for pelletizing animal feeds.

In Alberta, M-I Drilling Fluids Canada, Inc. recovers swelling bentonite from the Edmonton Formation of Upper Cretaceous age. The deposits are in the Battle River Valley, 14 km south of Rosalind, the site of the company's processing plant. The bentonite is mined selectively from relatively shallow paddocks or pits in the dry summer months. Some natural drying may be done by spreading and harrowing material before trucking it to the plant for drying, pulverizing and bagging. This bentonite, of intermediate swelling quality, may be used as a foundry clay, as a sealer for farm reservoirs, as feed pelletizing material, as a drilling-mud additive, as an additive to water for fire fighting and as a soil stabilizer.

WORLD DEVELOPMENTS

World production of bentonite and fuller's earth is dominated by the United States. The United States alone accounts for 51 and 76% of the total production of bentonite and fuller's earth in the world, respectively. Other major producers of bentonite include: Greece, Japan, Italy, Mexico; and of recent, Brazil. The United Kingdom is the only other significant fuller's earth producer country.

In 1987, the United States had 16 sodium bentonite and 10 calcium bentonite plants installed. Their annual production capacities total 5.1 Mt and 596 000 t, respectively, although due to severely depressed oil and gas exploration, much of this installed capacity has been mothballed.

Deposits in Wyoming account for more than two-thirds of total United States production. The Cretaceous Fort Benton Formation has traditionally provided the world's most outstanding sodium (swelling) bentonite. Calcium bentonite is mined primarily in Mississippi, California, Alabama and Georgia. A variety of fuller's earth, mainly comprising attapulgite, a lath-shaped clay mineral, is produced primarily in Georgia and Florida.

In 1987, American Colloid Company purchased the Colony, Wyoming operation from Applied Industrial Materials Corporation for $10 million. Earlier in the year American Colloid bought the clay desiccant product line from Culligan International Co. as a part of a continuing effort to diversify into other areas of value-added minerals. Oil-Dri Corporation of America purchased Ahschutz Mining Corporation, near Ochlocknee, Ga., for $1.75 million. This purchase included the mine and plant at Ochlocknee, adjacent to Oil-Dri's facilities, and all land and mineral leases. Subsequently, Oil-Dri announced its intentions to expand these existing facilities beginning in 1988. In another acquisition, United States Borax & Chemical Corporation, a subsidiary of RTZ Corporation PLC, purchased Pennsylvania Glass Sand Corp.'s subsidiary, Floridin Co. Floridin is a major producer of attapulgite-type fuller's earth used primarily in absorbents and drilling mud markets.

USES AND SPECIFICATIONS

Bentonite, in addition to having many uses by itself also serves as a minor constituent to impart favourable characteristics to many products. By and large, well-drilling muds represent the largest market for swelling bentonite. Synthetic bentonite (sodium-exchanged calcium bentonites) may also be used in special muds, depending upon cost and availability of natural swelling bentonites. The mineral's prime function is to increase the suspending powers of water-based muds. This enables drill cuttings to be brought to the surface and also prevents weighting agents such as barite from settling out when drilling has halted. A second function played by bentonite in drilling mud is to deposit a waterproof film on the walls of the bore-hole and so render formations impermeable. Its thixotropic properties, therefore, prevent circulation losses of the drilling fluid. Finally, the addition of bentonite increases viscosity which helps cool and lubricate the drill bit. The required muds contain approximately 10% bentonite. API specifications include: a maximum 2.5% plus 200 mesh; 12% moisture content; a minimum 8 c.p.I. plastic viscocity; and filter loss maximum 14 m.l.

Swelling bentonite finds its second greatest application as a binder in the pelletizing of iron ore concentrates. Bentonite's high "green" strength resulting from its plasticity and high "dry" strength resulting from its capacity to absorb and then give off moisture is the principal reason for its use. About 8 kg is used in every tonne of concentrate to provide pellets with sufficient strength to withstand handling, the drying and firing stages of pelletization, although quantities required vary with mineralogy and particle size of the concentrate. Desired bentonite specifications for this use include: 80% minus 200 mesh; moisture content maximum of 8%; minimum pH of 8.0; and minimum yield of 80-120 bb/t.

Swelling bentonite also serves as a binder in moulding sands used in iron and steel foundries. Similarly, this type of bentonite serves as a binder in feed stock. Small quantities are used as a plasticizer in abrasive and ceramic mixes and as a filler in paints, paper, rubber, pesticides, cosmetics, medicinal products, and cleaning and polishing compounds. Engineering applications include: grout for sealing subsurface waterbearing zones, dams and reservoirs; as additives to cements, mortars and concretes to suppress bleeding of the mixing water; as a compacting agent for gravels and soils and as a ground stabilizing medium for excavations when used in a bentonite-water suspension. Bentonite slurry is also effective in fighting forest fires.

Some non-swelling bentonite is used in moulding sands in iron and steel foundries, in pelletizing feed stock, as a carrier and diluent for pesticides, and as a cleaning powder for animals.

Activated bentonite is used in decolourizing mineral and vegetable oils, mineral fats, waxes, beverages and syrups. In some countries it is also used as a catalyst in the refining of fluid hydro-carbons.

OUTLOOK

Demand for well drilling grade bentonite has been very volatile in the past, however, 1987 industry results indicate that oil and gas exploration has probably bottomed out. By 1990, the United States will probably average 1200 active drill rigs, 23.0% higher than in 1986. Bentonite consumption should show similar growth, however, new mud systems using polymers may reduce unit consumption per footage drilled.

The foundry business depends on the automotive and construction sector. While the trend towards plastics and lighter metals has not relented, bentonite consumption will depend on the volume of ferrous metal cast. Modest growth over the long-term of between 2 and 4% annually is forecast.

Demand for pelletizing grade bentonite is expected to decline over the next decade. Several North American iron ore pellet plants have switched to organic binders and other mines have been testing various alternatives to bentonite as binders in their pellets.

PRICES

United States bentonite prices according to **Chemical Marketing Reporter,** December 28, 1987

	$
Bentonite, domestic, bulk, carlots, f.o.b. mines West Coast, per short ton	43.50

f.o.b. Free on board.

TABLE 1. CANADA, BENTONITE IMPORTS 1984-87[1] AND CONSUMPTION, 1982-86

	1984		1985		1986		1987	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Production	66 639	..	65 129	..	72 026	709	88 347	1 151
Imports							(Jan. - Sept.)	
Bentonite								
United States	243 746	10 050	280 868^{r}	14 304	228 365	10 153	154 483	6 752
Greece	93 194	5 226	64 901	3 707	97 853	5 286	49 200	2 465
West Germany	91	29	177	85	39	5	75	14
United Kingdom	23	2	-	-	5	..	-	-
Other	-	-	72	13	36	11	18	6
Total	337 054	15 307	346 018^{r}	18 109	326 298	15 455	203 776	9 237
Activated clays and earths								
United States	10 180	8 047	10 728	11 354	9 496	8 800	8 211	7 103
France	2 398	2 062	1 703	1 554	2 130	1 892	2 522	2 114
West Germany	1	1	506	370	557	299	316	225
Netherlands	-	-	-	-	-	-	13	23
United Kingdom	-	-	1	2	2	13	4	5
Total	12 579	10 110	12 938	13 280	12 183	11 003	11 065	9 470
Fuller's earth								
United States	4 151	525	4 969	577	5 437	452	6 68	498

Consumption[2] (available data)	1982	1983	1984	1985	1986P
			(tonnes)		
Iron ore pelletizing	127 737^{r}	112 181	138 328^{r}	149 970	144 477
Foundries	29 042	46 173	57 073	54 756	53 717
Well drilling	21 860	34 917	46 472	63 918	33 638
Fertilizer stock and poultry feed	158	221	2 420	2 657	2 498
Refractory	556	1 058	1 085	870	879
Other products[3]	2 913	2 879	3 275	3 614	2 681
Total	182 266	197 429	248 653^{r}	275 725	237 890

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Figures for 1987 include first nine months only. [2] Does not include activated clays and earths or fuller's earth. [3] Refractory brick mixes, cements, heavy clay products, rubber products, chemicals, paper products and other miscellaneous minor uses.
- Nil; P Preliminary; ^{r} Revised; .. Not available.

TABLE 2. CANADA, BENTONITE IMPORTS[1] AND CONSUMPTION[2], 1970, and 1975-87

	Imports		Consumption
	(tonnes)	($000)	(tonnes)
1970	351 066	5 590	285 671
1975	287 886	9 388	286 109
1976	367 162	10 244	335 553
1977	481 213	13 757	346 698
1978	367 931	14 893	264 894
1979	655 043	29 571	345 083
1980	490 714	27 982	248 585
1981	326 456	22 088	286 359
1982	252 481	22 100	182 266
1983	199 967	19 924	197 429
1984	353 784	25 942	265 289
1985	363 915r	31 966r	275 725
1986	343 918	26 910	237 890
1987[3]	221 521	19 205	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Includes bentonite, fuller's earth and activated clays and earths. [2] Includes only bentonite and fuller's earth. [3] First 9 months of 1987 only.
.. Not available; r Revised.

TABLE 3. WORLD PRODUCTION OF BENTONITE, BY COUNTRY 1983-85

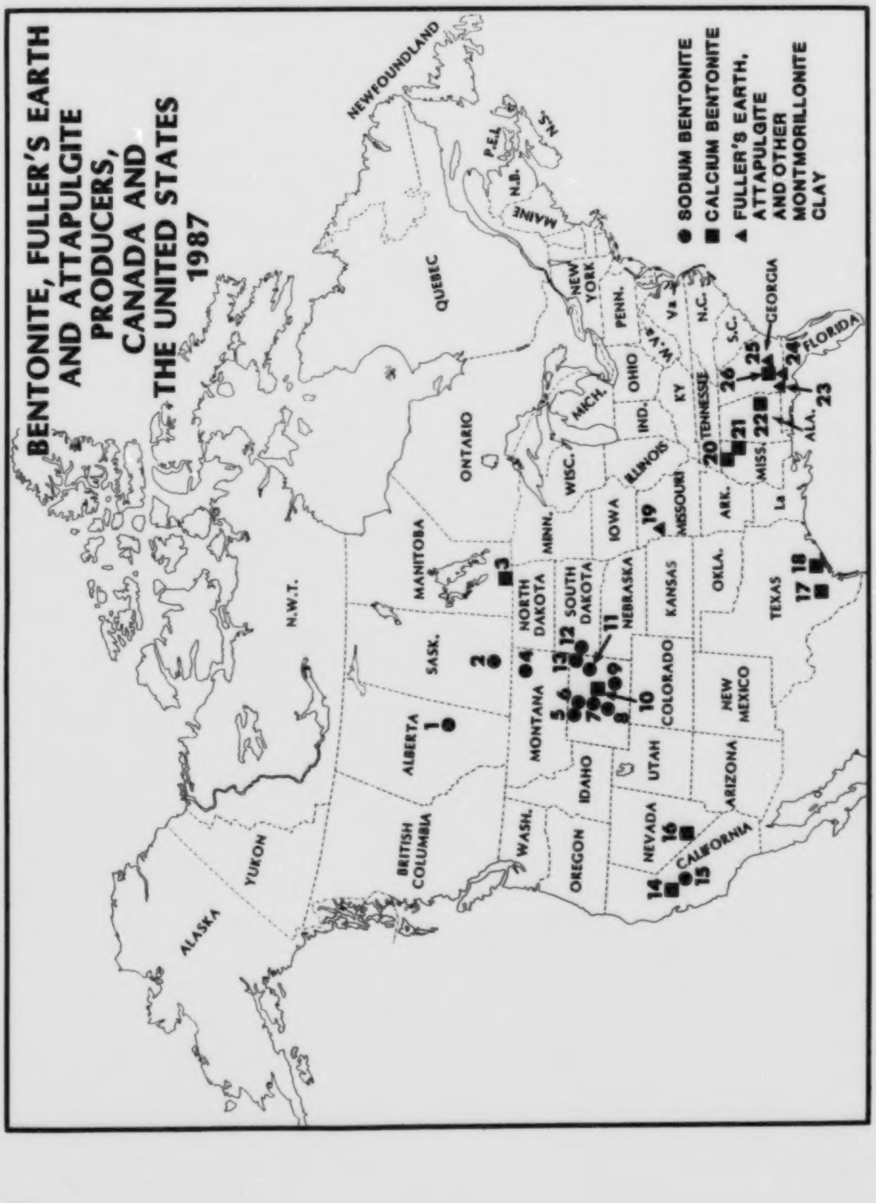
	1983	1984	1985
		(tonnes)	
United States	2 619	3 119	2 899
Greece	689	778	750
Japan	441	410	461
Italy	297	309	299
Mexico	226	267	254
Brazil	129	201	200
Romania	177	180	180
Rest of world	663	627	623
Total world	5 241	5 891	5 666

Source: U.S. Bureau of Mines.

TABLE 4. WORLD PRODUCTION OF FULLER'S EARTH, BY COUNTRY, 1983-85

	1983	1984	1985
		(tonnes)	
United States	1 734	1 723	1 868
United Kingdom	192	286	299
Senegal (attapulgite)	100	115	116
Mexico	42	46	45
Spain	27	33	34
Rest of world	98	91	91
Total world	2 193	2 294	2 453

Source: U.S. Bureau of Mines.



ALASKA
YUKON
N.W.T.
BRITISH COLUMBIA
ALBERTA
SASK.
MANITOBA
ONTARIO
QUEBEC
NEWFOUNDLAND
N.B.
P.E.I.
N.S.
MAINE
NEW YORK
PENN.
OHIO
MICH.
IND.
WISC.
ILLINOIS
KY
W.VA.
Va
N.C.
S.C.
GEORGIA
FLORIDA
ALA.
MISS.
TENNESSEE
ARK.
La
MISSOURI
IOWA
MINN.
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLA.
TEXAS
NEW MEXICO
COLORADO
ARIZONA
UTAH
NEVADA
IDAHO
MONTANA
WASH.
OREGON
CALIFORNIA
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BENTONITE, FULLER'S EARTH AND ATTAPULGITE PRODUCERS, CANADA AND THE UNITED STATES 1987

- ● SODIUM BENTONITE
- ■ CALCIUM BENTONITE
- ▲ FULLER'S EARTH, ATTAPULGITE AND OTHER MONTMORILLONITE CLAY

	Company	Parent Corporation	Plant Capacity (t/y)	Product
1.	M-I Drilling Fluids Canada, Inc.	Dresser Industries, Inc. and Halliburton Company	36 000	Sodium Bentonite
2.	Avonlea Mineral Industries Ltd.	-	60 000	Sodium Bentonite
3.	Pembina Mountain Clays Incorporated	Harshaw-Filtrol Corporation	35 000	Calcium Bentonite
4.	Federal Bentonite Division	Aurora Industries Incorporated	136 000	Sodium Bentonite
5. a)	American Colloid Company	-	454 000	Sodium Bentonite
b)	Baroid Division of NL Industries, Inc.	NL Industries, Inc.	n.a.	Sodium Bentonite
c)	Wyo-Ben Incorporated	-	450 000	Sodium Bentonite
6. a)	M-I Drilling Fluids Canada, Inc.	Dresser Industries, Inc. and Halliburton Company	390 000	Sodium Bentonite
b)	Wyo-Ben Incorporated	-	250 000	Sodium Bentonite
7.	Kaycee Bentonite Corporation	-	450 000	Sodium Bentonite
8.	Wyo-Ben Incorporated	-	91 000	Sodium Bentonite
9. a)	Kaycee Bentonite Corporation	-	(1)	Sodium Bentonite
b)	Benton Clay Company	Georgia Kaolin Co., Inc.	55 000	Sodium Bentonite
10.	Kaycee Bentonite Corporation	-	500 000	Sodium Bentonite
11.a)	American Colloid Company	-	454 000	Sodium Bentonite
b)	Federal Bentonite Division	Aurora Industries Incorporated	136 000	Sodium Bentonite
12.	American Colloid Company	-	454 000	Sodium Bentonite
13.a)	Baroid Division of NL Industries, Inc.	NL Industries, Inc.	544 000	Sodium Bentonite
b)	Federal Bentonite Division	Aurora Industries Incorporated	272 000	Sodium Bentonite
c)	IMC Industry Group	International Minerals & Chemical Corporation	450 000	Sodium Bentonite
14.	Wilbur-Ellis Company	-	50 000	Calcium Bentonite
15.	Wilbur-Ellis Company	-	35 000	Sodium Bentonite
16.	Industrial Mineral Ventures, Inc.	Gulf Resources & Chemical Corporation	90 000	Calcium Bentonite
17.	Southern Clay Products Inc.	English China Clays plc	27 000	Calcium Bentonite
18.	Milwhite Co.	-	3 000	Calcium Bentonite
19.	IMC Industry Group	International Minerals & Chemical Corporation	n.a.	Fuller's Earth
20.	Oil-Dri Corporation of America	-	n.a.	Calcium Bentonite
21.a)	American Colloid Company	-	136 000	Calcium Bentonite
b)	IMC Industry Group	International Minerals & Chemical Corporation	145 000	Calcium Bentonite
22.	American Colloid Company	-	145 000	Calcium Bentonite
23.	Engelhard Metals Corporation	-	454 000	Attapulgite
24.	United States Borax & Chemical Corporation	RTZ Corporation PLC	n.a.	Fuller's Earth and Attapulgite
25.a)	Oil-Dri Corporation of America	-	590 000	Attapulgite
b)	United States Borax & Chemical Corporation	RTZ Corporation PLC	n.a.	Attapulgite
26.a)	Oil-Dri Corporation of America	-	(2)	Calcium Bentonite
b)	United States Borax & Chemical Corporation	RTZ Corporation PLC	n.a.	Calcium Bentonite

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(1) Combined capacity with 7. Kaycee Bentonite Corporation (2) Combined capacity with 25.a) Oil-Dri Corporation of America.
n.a. Not available.

Cadmium

A. BOURASSA

Cadmium metal is recovered principally as a by-product of zinc smelting and refining. Cadmium is a relatively rare element in the earth's crust, occurring most commonly as the sulphides greenockite and hawleyite which are found associated with zinc sulphide ores, particularly sphalerite. There are no ores specifically mined for cadmium. Reserves at any time are a function of zinc reserves.

Smelter residues from which cadmium is extracted may be stockpiled in times of low demand with the result that refined cadmium production is not always directly related to production of the principal metals. During the past seven years, cadmium production in Canada has varied from 2.1 to 2.7 kg of cadmium for each tonne of zinc metal produced. Cadmium is now recovered at all four Canadian zinc smelters and at the Brunswick Mining and Smelting Corporation Limited lead smelter. Brunswick has recently announced that it plans to build a facility to convert cadmium bearing dust into a saleable sponge before 1990. The projected cadmium production is 200 t/y. Because of the involuntary production of cadmium with zinc, cadmium production is limited in its ability to respond to market conditions. Prices are therefore susceptible to wide fluctuations.

Cadmium metal is produced in varying shapes and degrees of purity for various uses. The most common forms are balls, sticks, slabs, ingots, rods and sponge.

Health and Environment

Cadmium is toxic, and care must be taken during the production and use of cadmium and its compounds, to ensure that exposure to fumes, dusts and effluents is minimized. It releases fumes during thermal treatment which quickly oxidize and these can be inhaled or ingested. Acute exposure can be very toxic, causing irreversible kidney damage, but there is said to be insufficient evidence to consider cadmium as an occupational carcinogen. Its toxicity was publicized in the early 1960s when nearly 100 persons in Japan died from itai-itai disease. Sophisticated methods are now available to measure cadmium in the workplace and in humans.

Most governments including Canadian provincial governments have put in place regulations to limit cadmium exposure, especially for workers. There is now a growing trend for governments to try to further restrict cadmium use and presence. The European Economic Community is now considering a program that will limit the use of cadmium where substitutes are available and encourage research for substitutes where none now exists. Countries like the Netherlands go even further by banning the production, importation and storage of some products, and severely restricting others with a view to a future ban.

Canada in 1986 was the non-socialist world's third largest producer of cadmium metal, after Japan and the United States. The next two largest producers were Belgium and the Federal Republic of Germany. Production of cadmium in the non-socialist world, as reported by the World Bureau of Metal Statistics, increased in 1986 to 14 686 t from 14 153 t in 1985. While data is not yet available for 1987, non-socialist world production is estimated to be marginally lower than in 1986 and Canadian production is estimated at 1 690 t.

USES

Cadmium is a soft, ductile, silver-white, electropositive metal. It is used mainly for coating iron and steel products to protect them against oxidation. Cadmium coatings may be applied by electroplating, mechanical plating or vacuum and ion deposition. The high ductility of cadmium is an advantage where the plated parts are to be formed. The good soldering characteristics of cadmium plate is an advantage in electrical applications. A cadmium coating, like a zinc coating, protects metals that are lower in the electromotive series by physical enclosure and by sacrificial corrosion. Cadmium is

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preferred to zinc as a coating for some applications because it is more ductile, can be applied more uniformly in recesses of intricately shaped parts, has a more aesthetic appearance and gives greater protection with the same thickness of plating than with zinc plating. Cadmium coatings are particularly useful in the electrical, electronic, automotive and aerospace industries.

The second largest use, according to the Statistics Canada survey, is in the manufacture of pigments and chemicals. Cadmium sulphides are used in yellow to orange colours and cadmium sulphoselenides for pink, red and maroon. Cadmium-containing pigments demonstrate good reflectance, heat stability and colour intensity. Cadmium compounds are used as stabilizers in the production of plastics and cadmium phosphors are used for picture tubes in television sets.

Cadmium-bearing rechargeable alkaline batteries, such as nickel-cadmium, silver-cadmium and mercury-cadmium, have the advantage of long life, maximum current delivery with a low voltage drop, small size, excellent performance under a wide temperature range and a low rate of self-discharge. They find wide use in aircraft, satellites, missiles, calculators, and a broad assortment of portable tools and appliances. This use now accounts for about 36% of total world consumption compared to 10% 15 years ago.

Other uses for cadmium are catalysts in the production of primary alcohols and esters; low melting point alloys used in fire detection; bearing alloys, brazing alloys and solders; and copper hardeners for railway catenary and trolley wires.

MARKET AND PRICES

North American prices, which are quoted on a delivered basis, are best represented by the "U.S. Producer" quotations published in Metals Week, and European prices by the "European sticks, free market price" quoted by Metal Bulletin. All quoted prices are for cadmium having a minimum purity of 99.95%.

Prices dropped under $1.00/lb. in April but rebounded to $3.30 by the end of the year. Strong demand, especially for nickel-cadmium batteries, brought about this turnaround. Cadmium consumption in market economy countries is now over 16 500 t/y, up from 15 500 t in 1986. This compares with an estimated production of about 14 400 t in 1987, down 2% from 1986. Stocks were estimated at 2 870 t in March 1987 but had fallen to 2 393 t by June. Adding to the tight supply situation, China ceased exporting this year while the Eastern Bloc is increasing its purchases.

OUTLOOK

In the long term, the cadmium supply will continue to be dependent on trends in the zinc industry. As the level of metal production is determined by the amount of zinc metal production, no significant increase is expected in the foreseeable future. Since demand by the nickel-cadmium battery manufacturers is expected to remain strong, notably in Japan, cadmium prices should remain strong. China will open its first nickel-cadmium battery plant in 1988 and the U.S.S.R. has recently bought nickel-cadmium battery technology and is therefore likely to increase its use of cadmium. In addition China recently opened a cadmium pigment plant in Shanghai. This points to a good potential for prices to increase beyond the $3.30/lb. level reached at the end of the year.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
CANADA					
32900-1	Cadmium in ores and concentrates	free	free	free	free
35102-1	Cadmium metal, not including alloys, in lumps, powders, ingots or blocks	free	free	25	free
UNITED STATES					
601.66	Cadmium in ores and concentrates		free		
632.14	Cadmium metal, unwrought, waste and scrap		free		
632.86	Cadmium alloys, unwrought containing by weight 96% or more, but less than 99% silicon		9		
632.88	Cadmium alloys, unwrought, other		5.5		
633.00	Cadmium metal, wrought		5.5		
EUROPEAN ECONOMIC COMMUNITY (MFN)			1987	Base Rate	Concession Rate
				(%)	
26.01	Cadmium in ores and concentrates		free	free	free
81.04	Cadmium metal, unwrought, waste and scrap		4	4	4
	Cadmium metal, other		6	6	6
JAPAN (MFN)					
26.01	Cadmium in ores and concentrates		free	free	free
81.04	Cadmium metal:				
	Unwrought		5.1	10	5.1
	Waste and scrap		4.8	10	4.8
	Powders and flakes		5.8	10	5.8
	Cadmium metal, other		6.5	15	6.5

Sources: The Customs Tariff, January 1987. Revenue Canada, Customs & Excise; Tariff Schedules of the United States Annotated 1987, USITC Publication 1910; U.S. Federal Register, Vol. 44, No. 241; Official Journal of the European Communities, Vol. 29, L 345, 1986; Customs Tariff Schedules of Japan, 1987.

TABLE 1. CANADA, CADMIUM PRODUCTION, EXPORTS AND DOMESTIC SHIPMENTS, 1970, 1975 AND 1980-87

	Production		Exports Cadmium Metal
	All Forms[1]	Refined[2]	
		(kilograms)	
1970	1 954 055	836 745	702 630
1975	1 191 674	1 142 508	637 797
1980	1 033 000	1 302 955	1 095 825
1981	833 788	1 293 265	1 452 904
1982	886 055	1 162 390	769 530
1983	1 107 000	1 296 000	1 365 111
1984	1 605 300	1 756 707	1 369 422
1985	1 716 731	1 696 192	1 477 416
1986	1 483 907	1 565 375	1 382 809
1987P	2 293 579	1 690 500	862 992[3]

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Production of refined cadmium from domestic ores plus recoverable cadmium content of exported ores and concentrates. [2] Refined metal and cadmium sponge from all sources. [3] For the January to September period.

TABLE 2. CANADA, CADMIUM METAL CAPACITY, 1986

Company and Location	Annual Capacity
	(tonnes)
Cominco Ltd. Trail, British Columbia	640
Canadian Electrolytic Zinc Limited Valleyfield, Quebec	550
Falconbridge Limited Timmins, Ontario	650
Hudson Bay Mining and Smelting Co., Limited Flin Flon, Manitoba	160
Total Canada	2 000

TABLE 3. CANADA, CADMIUM PRODUCTION AND EXPORTS, 1985-87, AND CONSUMPTION, 1984-86

	1985		1986		1987P	
	(kilograms)	000$	(kilograms)	000$	(kilograms)	000$
Production						
All forms[1]						
Ontario	898 297	3 268	807 457	3 086	1 511 800	8 602
British Columbia	193 443	703	304 468	1 163	340 000	1 934
Manitoba	181 539	660	118 437	452	115 185	655
Quebec	123 839	450	43 743	167	89 500	509
New Brunswick	67 081	244	27 222	104	60 854	346
Saskatchewan	13 111	47	5 281	20	1 190	7
Northwest Territories	238 042	865	175 211	670	160 200	912
Newfoundland	-	-	-	-	10 200	58
Yukon	1 379	5	2 008	8	4 650	26
Total	1 716 731	6 245	1 483 907	5 673	2 293 579	13 050
Refined[2]	1 696 192	..	1 565 375	..	1 690 500	..
Exports					(Jan.-Sept.)	
United States	906 034	2 875	1 042 817	3 731	692 902	3 050
United Kingdom	460 236	1 109	234 587	651	110 272	316
Netherlands	110 952	347	104 870	242	58 295	149
Others	196	23	535	62	1 523	62
Total	1 477 418	4 356	1 382 809	4 686	862 992	3 577

	1984	1985	1986P
		(kilograms)	
Consumption			
Cadmium metal[3]			
Plating	13 327	15 854	13 219
Solders	2 107	3 353	1 583
Other uses[4]	8 576	10 475	1 270
Total	24 010	29 682	16 072

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Production of refined cadmium from domestic ores, plus recoverable cadmium content of exported ores and concentrates. [2] Refined metal from all sources and cadmium sponge. [3] Available data reported by consumers. [4] Mainly chemicals, pigments and alloys other than solder.

P Preliminary; - Nil; .. Not available.

TABLE 4. CADMIUM METAL PRICES, 1986 AND 1987

Month	Average Monthly Prices Metals Week U.S. Producer	 Metal Bulletin European Free Market - Sticks
	(US$/lb.)	
1986		
January	1.00	0.78-0.83
February	1.00	0.76-0.81
March	1.00	0.78-0.82
April	1.17	1.04-1.09
May	1.35	1.08-1.14
June	1.35	1.03-1.08
July	1.35	0.94-0.99
August	1.35	0.89-0.94
September	1.35	0.96-1.01
October	1.35	0.97-1.01
November	1.35	0.87-0.92
December	1.35	0.86-0.91
Average	1.25	0.91-0.96
1987		
January	1.35	0.88-0.92
February	1.35	0.76-0.93
March	1.25	0.89-0.92
April	1.26	0.99-1.06
May	1.43	1.51-1.62
June	1.88	1.55-1.61
July	1.88	1.53-1.58
August	1.94	1.84-1.95
September	2.25	2.19-2.27
October	2.79	2.53-2.73
November	3.25	2.91-3.02
December	3.25	3.02-3.10
Average	1.99	1.73-1.81

Sources: Metals Week; Metal Bulletin.

TABLE 5. WESTERN WORLD CADMIUM METAL PRODUCTION, 1983-87

Continent and Country	1983	1984	1985	1986	(Jan.-June) 1987P
		(tonnes)			
Europe					
Austria	46	48	53	48	24
Belgium	1 217	1 450	1 293	1 374	701
Finland	616	614	564	523	263
France	447	447	365	444	170
Germany, F.R.	1 094	1 111	1 095	1 218	580
Italy	386	515	360	321	162
Netherlands	513	636	598	565	257
Norway	117	152	164	154	71
Spain	278	290	268	247	155
United Kingdom	340	390	370	379	247
Yugoslavia	48	48	48	48	24
Africa					
Algeria	30	24	24	24	12
Namibia	51	41	60	75	n.a.
Zaire	308	300	280	280	180
Asia					
India	131	143	190	160	107
Japan	2 215	2 400	2 555	2 542	1 222
Republic of Korea	460	460	460	460	230
Turkey	10	12	16	16	8
Americas					
Canada	1 296	1 774	1 712	1 554	840
Mexico	847	894	852	764	327
Peru	443	n.a.	n.a.	n.a.	n.a.
United States	1 382	2 066	1 678	2 352	996
Other Americas	210	249	269	870	129
Australia	1 104	1 060	879		398
Western World	13 589	15 123	14 153	14 686	7 162

Sources: World Bureau of Metal Statistics.
P Preliminary; n.a. Not available.

Cement

O. VAGT

SUMMARY

In 1987, both the value of residential and non-residential construction in Canada continued an upward trend begun in the latter part of 1984. Demand for cement followed a similar trend and consumption was more than 8.5 Mt, about the same as record levels reached in the mid-1970s. Total cement shipments increased to more than 12 Mt and exports to the United States of both cement and clinker increased marginally.

Canadian cement production capacity remained at 16.54 Mt/y. Production efficiency and the relatively strong American dollar combine to make Canadian cement and clinker competitive in bordering states.

Canada's economy recovered substantially since the 1982-84 recessionary period. Since 1985, construction expenditures related particularly to residential building expanded rapidly. The commercial and institutional building sectors performed reasonably well, however expenditures related to engineering construction, with gas and oil facilities accounting for up to one-third, continued to be relatively low.

THE CANADIAN INDUSTRY

The Canadian cement industry, now 83% foreign-controlled, is strongly regionalized with capacity concentrated near growth areas, some of which are convenient to United States market access. Some plants in fact, were located for ready access to existing United States markets by utilizing waterborne, high-bulk transportation facilities. In 1986, S.A. Cimenteries CBR of Belgium purchased the cement assets of Genstar Cement Limited, now CBR Cement Canada Limited, representing 16% of domestic capacity. Also, Société des Ciments Français, the second largest cement company in France, bought Lake Ontario Cement Limited which accounts for 9% of capacity. In the case of Genstar, plants in the "inland" western provinces are now referred to by their original name, Inland Cement Limited. In British Columbia, CBR's cement operations conduct business under the name of Tilbury Cement Limited with production facilities in Delta and distribution centres throughout the province.

St. Lawrence Cement Inc.'s acquisitions of cement plants in New York and Maryland in 1984-85, along with cement distribution terminals, increased capacity substantially which in the United States remains at about 1.1 Mt. Most recently, capital expenditures were made principally to upgrade production facilities and the concrete ready-mix fleet. The company continues to ship into the northeastern region from its Canadian plants.

St. Marys Cement Company has two United States affiliates, St. Marys Wyandotte Cement Inc. and St. Marys Wisconsin Cement Inc. The former operates a 300 000 t/y grinding plant near Detroit, the latter a 150 000 t/y grinding plant in Milwaukee and distribution terminals in Green Bay, Wisconsin and Waukegan, Illinois.

A typical feature of the Canadian cement industry is its diversification and vertical integration into related construction and construction materials fields. Many cement manufacturers also supply ready-mix concrete, stone, aggregates and concrete products such as slabs, bricks and prestressed concrete units.

Lake Ontario Cement Limited, for example, is well integrated into the concrete products field and continued this policy through the Building Products Group. The acquisition in 1986 of Universal Concrete Products Inc., of Columbus, Ohio, provides a major extension of the companys current market area as far south as the Carolinas. Also, acquisitions of ready-mix operations in North Bay, Ottawa and Maitland were initiated and completed in the period 1985 to 1987.

Three plants in the **Atlantic region**, which obtain raw materials on site or nearby, constitute just over 5% of total Canadian clinker producing capacity. North

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Star Cement Limited largely completed extensive renovation for improving fuel efficiency at its Corner Brook, Newfoundland plant. Canada Cement Lafarge Ltd.'s (CCL) plant at Brookfield, Nova Scotia provided clinker based on requirements of the company's plant at Havelock, New Brunswick. Regional consumption was about 400 000 t in 1986, a decrease of about 6% from the 1985 level.

In the **Quebec region,** five clinker-producing plants account for 25% of Canadian output in a region which in 1986 consumed about 1.9 Mt of portland cement or 26.4% of total Canadian consumption. At its St. Constant plant south of Montreal, CCL has experimented with alternate fuel as part of a program administered by the federal departments of Environment Canada and Energy, Mines and Resources Canada.

Miron Inc. continued to investigate new plant sites allowing decentralization away from urban concentration in Montreal. A long-term agreement was finalized with the Port Authority of Montreal allowing modifications to accommodate storage and handling of up to 200 000 t of cement and clinker at dockside. Imports of primary material clinker account for about 15% of present needs.

Portland cement consumption increased in the **Ontario region** where 40% of the nation's clinker-producing capacity is concentrated. Canada Cement Lafarge Ltd. has brought into production about 3 Mt of new cement capacity over the past eight years and most of its operating kilns are relatively new. Limestone for CCL's Bath, Ontario plant is quarried on-site and silica is supplied from Potsdam sandstone at Pittsburgh, about 65 km east of Bath. Iron oxide and gypsum are purchased from Hamilton and Nova Scotia, respectively. The Woodstock plant has experimented with the use of refuse-derived fuel (RDF). The plant obtains limestone on site, silica from Falconbridge Limited, iron oxide from Stelco Inc. and gypsum from southern Ontario.

At Picton, Lake Ontario Cement Limited operates one of the largest cement plants in North America. The four-kiln plant supplies cement and clinker to its associated companies in the United States - Rochester Portland Cement Corp. in New York state and Aetna Cement Corporation in Michigan - and cement to its Ontario markets.

For its Mississauga plant, St. Lawrence Cement Inc. obtains limestone from Ogden Point, 160 km east of Toronto on the shore of Lake Ontario. Gypsum is purchased from Nova Scotia or from southern Ontario mines.

Federal White Cement Ltd.'s plant at Woodstock, can produce up to 100 000 t/y of white cement.

Two companies, Canada Cement Lafarge Ltd. and CBR's Inland/Tilbury operations, operate a total of five clinker producing plants in the **Prairie region** and three in the **Pacific region** along with one clinker grinding plant. This **Western region** has 30% of clinker producing capacity, including the recently completed expansion at Inland's Edmonton, Alberta plant. Consumption of portland cement in the western provinces accounted for 31% of total Canadian use. Recent expansions at Edmonton and at Exshaw increased capacity by about 1.3 Mt/y.

Inland Cement Limited continued to increase the productive capacity at its Cadomin limestone property which supplies the Edmonton plant through a 4 500 t unit train and materials handling system. A limestone quarry at Mafeking, Manitoba, near the Manitoba-Saskatchewan border, supplies limestone to Inland's Regina plant, while the Winnipeg plant is supplied from Steep Rock, Manitoba.

CCL's Winnipeg plant obtains limestone from the company's quarry at Steep Rock on Lake Manitoba, gypsum from Westroc Industries Limited at Amaranth, silica from Beausejour and clay adjacent to the plant site at Fort Whyte. Raw material for the Exshaw plant is mainly from on-site but gypsum and iron oxide respectively, are from Westroc and Cominco Ltd. Limestone from Texada Island supplies the company's Vancouver plant at Richmond. The company's Kamloops plant is supplied from reserves close to the plant site.

NORTH AMERICAN TRADE

Exports of Canadian cement and clinker are mainly to the United States, in particular to the states of New York, Vermont, Michigan and Minnesota. Canadian cement production efficiencies and a relatively strong American dollar continue to make Canadian cement and clinker competitive in their own right in bordering states. Imports from Mexico, Spain and Venezuela have added to the concerns of the United States cement producers. Of protectionist measures considered in recent years, the Buy America provisions within the United States Surface Transportation Assistance Act, 1982 (STAA) were of particular concern to Canadian cement exporters. However, Congress lifted restrictions in March 1984 and Canadian cement has since been afforded full access to STAA-funded projects.

Major Canadian cement producers strengthened their United States position during the 1980s with acquisitions ranging from cement storage and distribution facilities and clinker grinding plants to full clinker producing and grinding capacity. In 1985, Lafarge Corporation, which wholly owns both Canada Cement Lafarge Ltd. in Canada and General Portland Inc. in the United States, announced its decision to close General Portland's Florida plants and to make up the lost production with imports from Mexico. In 1987, with new headquarters established in Reston, Virginia, Lafarge exercised its option to purchase the physical assets of the National Gypsum Company's cement manufacturing plant in Alpena, Michigan. Concurrent with the purchase, Lafarge Corporation acquired a remaining 50% interest in seven distribution terminals located in Michigan, Wisconsin, Illinois and Minnesota. This strengthening of the company's position in the Great Lakes region followed purchases the previous year of six cement distribution terminals in New York, Ohio and Michigan.

Reaction by the United States cement industry to higher imports resulted in lobbying for "fair trade vs. free trade" by the newly formed American Cement Trade Alliance (ACTA). This initiative was taken despite the fact that ACTA's membership accounted for 45% of total imports. However, petitions initiated by ACTA for anti-dumping duties against eight countries resulted in their rejection in December 1986 by the U.S. International Trade Commission, after one preliminary investigation. Apparently, the view taken was that "dumping" did not apply because competition was between U.S. distributors of cement and not between U.S. and foreign suppliers.

In response to unprecedented rapid changes mainly related to foreign ownership and record level imports of cement, the U.S. Department of Commerce published in 1987 some findings summarized as follows. The dramatic shift in the balance of U.S. cement trade resulted from additions of highly efficient cement capacity in several foreign countries; a concurrent lack of growth in cement demand in virtually every world market except the United States; and extremely low freight rates brought on by the long-term glut of ocean-going vessels. Furthermore, the low freight rates have not aided U.S. exports because of depressed overseas markets. Also, the reduced exchange value of the U.S. dollar has not offset import penetration as might have been expected. And in addition, the dollar has fallen against only a few major currencies and its value has actually strengthened against those of some exporting nations. As cited by the industry, other factors placing many U.S. cement producers at a disadvantage in their own market include high costs relating to pollution control, construction, and energy.

TECHNOLOGY

Research relating to cement manufacture is concentrated in the pyroprocessing sector accounting for over 80% of the energy requirements. Raw material grinding and finish grinding are being studied to determine optimum particle size for energy consumed. Energy conservation programs adopted by the Canadian cement industry more than reached the goal of a 9 to 12% reduction in energy consumption per unit of production, based on 1974 calculations. In 1986 the Canadian cement industry on average consumed 4 984 megajoules a tonne of production of which 4 414 megajoules was derived from fossil fuels.

The fuel mix has changed dramatically compared to 1974 when natural gas, petroleum products and coal/coke accounted for 49.5, 39.7 and 10.8% respectively. In 1986, percentages were 24.6, 5.0 and 70.4 respectively. Dry process plants accounted for 80.1% of total Canadian cement production in 1986.

Energy conservation demonstration projects funded through the Conservation and Non-Petroleum Sector of Energy, Mines and Resources Canada (EMR) have proven successful. One project dealt with the use of Coal Water Fuel in two cement kilns in Richmond, B.C. The initial aim was to replace a minimum of 60% of the natural gas used and the trial indicated 95% could be replaced resulting in coal consumption of 100 000 t/y. Also, an alternative energy project partially funded by EMR under the National Conservation Initiative, resulted in the use of methane gas produced in a landfill site. The gas is now providing 6 to 8% of the fuel needs of the kilns in Richmond, B.C. Industry is represented on the Industrial Minerals Task Force on Energy Conservation and continues to play an active role in this organization. Through the Canada Centre for Mineral and Energy Technology (CANMET), a branch of EMR, and through the Building Research Division of the National Research Council, a continuing program of concrete research is managed. Most research has been confined to strength determination, durability, placement and curing. Recently however, much work has concentrated on the use of superplasticizers, a group of admixtures described chemically as naphthalene or melanine sulphonate polymers. These provide greater workability over short periods and also provide high-strength by permitting lower water-cement ratios.

On-going research sponsored through CANMET and relating to supplementary cementing materials led to the successful use of blast furnace slag for manufacturing a slag cement. Reiss Lime Company of Canada, Limited is now producing this type of cement from a grinding plant at Spragg, Ontario, using granulated slag from The Algoma Steel Corporation, Limited's, Sault Ste. Marie plant. Plant capacity is 200 000 t/y of slag cement for complete or partial replacement of Portland cement, depending on requirements. The primary use at present is in mine backfill, however, construction-related uses are also being investigated.

Other cementing materials-related research involving CANMET mainly concerns fly ash and silica fume. One aspect here involves alkali reactivity and its influence on the durability of construction materials. This problem is of particular importance in regions where there are significant variations in the alkali content of cements or of the available raw materials needed for cement and aggregates. Also relating to CANMET R&D, about 30 corporate and other laboratories participate in detailed testing and analyses aimed at producing a reference cement available to all.

Research in the private sector is conducted on behalf of all cement producers by the Portland Cement Association (PCA), a non-profit research group sponsored by the cement industry. Individual producers generally have research facilities varying in size from a customer service unit to a large laboratory; in the case of Canada Cement Lafarge's new Montreal-based facility, mandated "to develop new manufacturing processes and improve cement and concrete products tailored to the Canadian and United States markets."

WORLD DEVELOPMENTS

World cement production in 1986 was 1 012 Mt, according to the U.S. Bureau of Mines. China ranked number one, leading all countries at 154 Mt, followed by the U.S.S.R. at 133 Mt and the United States at 73 Mt.

Most countries are capable of supplying their own raw material requirements for cement manufacture when a plant is warranted. Normally, the market area of a given producing plant is strictly limited by transportation costs, however large additional sales may warrant a secondary distribution terminal. Few countries rely entirely on imports for their cement needs, however in recent years multinational companies with widespread production and distribution networks have become much more important in world markets.

USES

Portland cement is produced by burning, usually in a rotary kiln, an accurately proportioned, finely ground mixture of limestone, silica, alumina and iron oxide. The three basic types of Portland cement, Normal Portland, High-Early-Strength Portland, and Sulphate-Resisting Portland, are produced by most Canadian cement manufacturers.

Cement has little use alone, but when combined with water, sand, gravel, crushed stone or other aggregates in proper proportions, acts as a binder for concrete. Concrete has become a readily adaptable material capable of being poured on-site for large engineering projects, or used in the form of delicate precast panels or as heavy, prestressed columns and beams in building construction.

Kiln discharge, in the shape of rough spheres, is a fused, chemically complex mixture of calcium silicates and aluminates termed clinker, which is mixed with gypsum (4 to 5% by weight) and ground to a fine powder to form portland cement. By close control of the raw mix, the burning conditions and of the use of additives in the clinker-grinding procedure, finished cements displaying various properties are produced.

Moderate Portland Cement and Low-Heat-of-Hydration Portland Cement, designed for concrete poured in large masses, such as in dam construction, are manufactured by several companies in Canada. Masonry cement (generic name) includes such proprietary product names as Mortar Cement, Mortar Mix (unsanded), Mason's Cement, Brick Cement and Masonry Cement. The latter product produced by Portland cement manufacturers is a mixture of Portland cement, finely ground high-calcium limestone (35 to 65% by weight) and a plasticizer. The aforementioned products do not necessarily consist of Portland cement and limestone, but may include mixtures of Portland cement and hydrated lime and/or other plasticizers.

Portland cement used in Canada should conform to the specifications of CAN 3-A5-M83, published by the Canadian Standards Association (CSA). This standard covers the five main types of Portland cement. Masonry cement produced in Canada should conform to the CAN 3-A8-M83. Blended hydraulic cements are covered by CAN 3-A362-M83. The cement types manufactured in Canada, but not covered by the CSA standards, generally meet the appropriate specifications of the American Society for Testing and Materials (ASTM).

OUTLOOK

Canada's economic recovery picked up considerably with an annual growth rate of about 6% during the first half of the year and 4% during the third quarter of 1987. Until this year however, recovery since 1982 lagged uncommonly far behind the United States. The construction industry in the United States became very active following the 1980-81 recession and demand for the materials of construction presented opportunities for Canadian producer-exporters cement, clinker, gypsum and gypsum wallboard. Canadian business investment remained low and construction expenditures, particularly in engineering projects actually decreased. Housing starts dropped to 125 860 in 1982, the lowest since 1961, rebounded to 162 645 in 1983, dropped again in 1984 to 134 900, rose to 165 826 in 1985 and to 199 785 in 1986. In 1987, housing starts are expected to be more than 240 000. Indicators including relatively low interest rates, falling unemployment and moderate consumer prices suggest a positive outlook for the building construction sector. Nevertheless, housing starts in 1988 are expected to decline substantially in Ontario and Quebec because pent-up demand from the recessionary period has been satisfied. The Alberta economy is making a significant recovery from a decline in oil and gas-related investment that took place in 1986 and this is expected to broaden the level of construction activity in the western region.

The Canadian Construction Association is predicting increases in the non-residential contract construction industry constant dollar expenditures of about 4% through the 1986-95 period. The construction industry as a whole has expressed concern for some time that Canada's large infrastructure network deserves attention now rather than delaying until major renovation and upkeep projects are needed. It is considered that a program would permit the construction industry, and the dependent portion of the mining industry, to plan five to ten years ahead with overall benefits in efficiency.

Conservation of energy and raw materials is of worldwide concern and is a factor influencing major developments in the industry. Of particular note is the emphasis on blended cements and the utilization of slag, ash and other by-products.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(cents per hundred pounds)		
CANADA					
29000-1	Portland and other hydraulic cement, n.o.p.; cement clinker	free	free	6	free
29005-1	White, nonstaining Portland cement	3.7	3.7	8	2.3
UNITED STATES (MFN)					
511.11	White, nonstaining Portland cement per 100 pounds including weight of container		1		
511.14	Other cement and cement clinker		free		
511.21	Hydraulic cement concrete		free		
511.25	Other concrete mixes, whether wet or dry per cubic yard		4.9%		

Sources: The Customs Tariff, 1987, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated 1987, USITC Publication 1910; U.S. Federal Register Vol. 44, No. 241.
n.o.p. Not otherwise provided for.

TABLE 1. CANADA, CEMENT PRODUCTION AND TRADE, 1985-87

	1985		1986		1987P	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Production[1]						
By province						
Ontario	4 092 753	283 677	4 437 345	343 086	5 201 000	413 671
Quebec	3 093 545	183 794	3 249 209	190 289	3 600 000	216 900
Alberta	1 142 852	148 881	949 354	113 371	1 075 000	132 061
British Columbia	988 498	74 818	1 071 108	73 696	1 247 000	88 288
Manitoba	342 963	35 725	415 192	43 733	451 000	48 868
Saskatchewan	..	19 237	..	16 684	..	17 904
Nova Scotia	..	21 079	..	25 430	..	39 509
New Brunswick	..	12 366	..	9 526	..	9 285
Newfoundland	..	8 779	..	8 530	..	9 541
Total	10 192 442	788 357	10 611 223	824 345	12 205 000	976 027
By type						
Portland	9 254 535	735 769	9 929 135	778 321	..	..
Masonry[2]	937 907	52 588	682 088	46 023	..	..
Total	10 192 442	788 357	10 611 223	824 344	..	
Exports					(Jan.-Sept.)	
Portland cement						
United States	2 478 046	127 772	2 608 829	134 741	2 032 665	99 327
Cameroon	1 017	87	984	69	-	-
Other countries	6 636	497	2 835	190	2 337	263
Total	2 485 699	128 356	2 612 648	135 000	2 035 002	99 590
Prestressed concrete structures						
United States	..	26 036	..	37 892	..	28 707
Others	..	74	..	69	..	168
Total	..	26 100	..	37 961	..	28 875
Cement and concrete basic products						
United States	..	55 625	..	57 949	..	45 133
Other countries	..	351	..	335	..	857
Total	..	55 976	..	58 284	..	45 990
Imports						
Portland cement, standard						
United States	210 954	15 986	194 682	15 042	224 016	14 805
Other countries	2 814	152	30 862	1 073	30 343	1 090
Total	213 768	16 380	225 544	16 115	254 359	15 895

TABLE 1. (cont'd)

	1985		1986		Jan.-Sept. 1987P	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
White cement						
United States	2 201	245	1 916	232	3 807	324
Japan	1 013	184	686	129	36	3
Other countries	915	118	1 499	130	1 382	163
Total	4 129	547	4 001	491	5 225	490
Aluminous cement						
United States	5 419	1 999	6 539	1 964	10 493	1 746
Other countries	-	-	-	-	-	-
Total	5 419	1 999	6 539	1 964	10 493	1 746
Cement, n.e.s.						
United States	50 417	4 489	47 919	4 844	35 286	3 571
United Kingdom	3 751	828	2 647	697	210	8
Japan	386	59	366	58	290	44
West Germany	72	18	80	22	16	12
Italy	20	5	5	1	38	9
France	530	31	-	-	-	-
Netherlands	-	-	6	11	-	-
Other countries	2	1	-	-	5	1
Total	28 931	3 077	51 023	5 633	35 845	3 645
Total cement imports	252 247	22 003	287 107	24 203	305 922	21 776
Cement and concrete basic products, n.e.s.						
United States	..	3 869		4 207	..	5 092
France	..	6	..	37	..	+
West Germany	..	148	..	110	..	72
United Kingdom	..	66	..	149	..	20
Belgium-Luxembourg	..	-	..	16	..	-
Other countries	..	96	..	25	..	76
Total	..	4 185	..	4 544	..	5 260
Cement clinker						
Spain	38 562	1 132	148 827	5 575	30 210	1 109
Greece	-	-	29 806	1 143	31 506	1 122
France	-	-	24 308	709	26 297	1 124
Venezuela	31 876	1 052	-	-	-	-
United States	-	-	85	3	339	10
Other	24 503	791	-	-	22 536	978
Total	94 941	2 975	203 026	7 430	118 090	4 343

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Producers' shipments plus quantities used by producers. [2] Includes amounts of clinker and other cement.

P Preliminary; .. Not available; + Amount too small to identify; - Nil; n.e.s. Not elsewhere specified.

TABLE 2. CEMENT PLANTS, APPROXIMATE ANNUAL GRINDING CAPACITY, END OF 1987

Company	Plant	Wet(W) Dry(D) Pre-heater(x) Precal-ciner(c)	Fuel (Coal Oil Gas)	No. of Kilns	Grinding Capacity	Clinker Capacity
					(000 tpy)	
Atlantic						
Canada Cement Lafarge Ltd.	Brookfield, N.S.	D	C,O	2	485	458
	Havelock, N.B.	D	C,O	2	315	300
North Star Cement Limited	Corner Brook, Nfld.	Dx	O	1	250	120
Atlantic Region Total				5	1 050	878
Quebec						
Canada Cement Lafarge Ltd.	St. Constant	D	O,G	2	955	902
Ciment Quebec Inc.	St. Basile	W,Dc	O	3	575	1 106
Miron Inc.	Montreal	D	O,G	2	1 000	840
St. Lawrence Cement Inc.	Beauport	W	C,O	2	550	598
(Independent Cement Inc.)	Joliette	D	C,O	4	1 000	976
Quebec Region Total				13	4 080	4 422
Ontario						
Canada Cement Lafarge Ltd.	Woodstock	W	C,G	2	535	505
	Bath	Dx	O,G	1	1 000	943
Federal White Cement Ltd.	Woodstock	D	O,C,G	1	100	100
Lake Ontario Cement Limited	Picton	D,Dx	C,G	4	744	1 419
St. Lawrence Cement Inc.	Clarkson	W,Dc	C,O,G	3	2 400	1 700
St. Marys Cement Company	Bowmanville	W	C	2	790	600
	St. Marys	W,Dx	O,G	3	800	990
Ontario Region Total				16	6 270	6 257
Prairies						
Canada Cement Lafarge Ltd.	Fort Whyte, Man.	W	O,G	2	565	532
	Exshaw, Alta.	D,Dc	G	3	1 230	1 184
	Edmonton, Alta.				220	
Inland Cement Limited-(CBR)	Winnipeg, Man.	W	O,G	1	325	310
	Regina, Sask.	D	O,C	1	375	214
	Edmonton, Alta.	W,Dc	G	4	2 040	1 186
Prairies Region Total				11	4 755	3 426
British Columbia						
Canada Cement Lafarge Ltd.	Kamloops	D	G,C	1	190	180
	Richmond	W	O,G	2	555	522
Tilbury Cement Limited-(CBR)	Tilbury Island	Dx	O,G	1	1 000	855
B.C. Region Total				4	1 745	1 557
Canada Total (9 companies)				49	17 900	16 540

Source: Market and Economic Research Department, Portland Cement Association.

TABLE 3. CANADA, CEMENT PLANTS, KILNS AND CAPACITY UTILIZATION, 1977-87

	Clinker Producing Plants	Kilns	Approximate Cement Grinding Capacity[1] (tpy)	Portland and Masonry Cement Production[2] (t)	Clinker Exports[3] (t)	Approximate Total Production[4] (t)	Capacity Utilization (%)
1977	22	49	14 885 000	9 639 679	775 145	10 414 824	72
1978	24	51	15 985 000	10 558 279	1 077 274	11 635 553	72
1979	24	51	15 985 000	11 765 248	1 530 537	13 295 785	83
1980	23	47	16 363 000	10 274 000	726 087	11 000 087	67
1981	23	48	16 771 000	10 145 000	524 006	10 669 006	64
1982	23	48	16 771 000	8 418 000	290 329	8 708 329	50
1983	23	49	17 900 000	7 870 878	404 793	8 275 671	46
1984	23	49	17 900 000	9 387 466	440 297	9 827 763	55
1985	23	49	17 900 000	10 192 442	676 596	10 869 040	61
1986	23	49	17 900 000	10 611 223	324 000	10 935 223	61
1987	23	49	17 900 000	12 205 000P	670 000e	12 875 000	72

Sources: Statistics Canada, U.S. Bureau of Mines, Portland Cement Association (PCA).
[1] Includes two plants that grind only. [2] Producers' shipments and amounts used by producers. [3] Imports to United States from Canada. [4] Cement shipments plus clinker exports.
e Estimated; P Preliminary.

TABLE 4. CANADA, HOUSE CONSTRUCTION, BY PROVINCE, 1985 AND 1986

	Starts			Completions			Under Construction		
	1985	1986	% Diff.	1985	1986	% Diff.	1985	1986	% Diff.
Newfoundland	2 854	2 883	1.0	1 852	2 400	29.6	3 348	3 823	14.2
Prince Edward Island	788	1 110	40.9	757	1 176	55.4	420	362	-13.8
Nova Scotia	6 923	7 571	9.4	5 748	7 571	31.7	3 474	3 435	-1.1
New Brunswick	4 142	4 045	-2.3	3 224	4 504	39.7	2 137	1 770	-17.2
Total (Atlantic Provinces)	14 707	15 609	6.1	11 581	15 651	35.1	9 379	9 390	0.1
Quebec	48 031	60 348	25.6	41 577	56 984	37.1	21 270	24 531	15.3
Ontario	64 871	81 470	25.6	50 590	69 567	37.5	36 761	48 625	32.3
Manitoba	6 557	7 699	17.4	5 081	7 341	44.5	3 817	4 178	9.5
Saskatchewan	5 354	5 510	2.9	5 653	5 072	-10.3	2 866	3 255	13.6
Alberta	8 337	8 462	1.5	7 517	9 172	22.0	3 518	2 913	-17.2
Total (Prairie Provinces)	20 248	21 671	7.0	18 251	21 585	18.3	10 201	10 346	1.4
British Columbia	17 969	20 687	15.1	17 107	20 818	21.7	8 755	8 548	-2.4
Total Canada	165 826	199 785	20.5	139 106	184 605	32.7	86 366	101 440	17.5

Source: Canada Mortgage and Housing Corporation.

TABLE 5. CANADA, VALUE OF CONSTRUCTION[1] BY TYPE, 1985-87

	1985	1986	1987
		($ millions)	
Building Construction			
Residential	24 145	28 637	29 281
Industrial	3 470	3 129	2 996
Commercial	8 697	9 865	10 744
Institutional	3 119	3 488	3 697
Other building	2 028	1 883	1 972
Total	41 459	47 002	48 690
Engineering Construction			
Marine	379	387	473
Highways, airport runways	5 179	5 029	5 216
Waterworks, sewage systems	2 481	2 258	2 488
Dams, irrigation	283	272	273
Electric power	3 314	3 649	3 964
Railway, telephones	2 787	2 627	2 903
Gas and oil facilities	9 207	6 638	5 683
Other engineering	2 894	2 544	2 658
Total	26 524	23 404	23 658
Total construction	67 983	70 406	72 348

Source: Statistics Canada.

[1] Actual expenditures 1985, preliminary actual 1986, intentions 1987.

TABLE 6. CANADA, VALUE OF CONSTRUCTION[1] BY PROVINCE, 1985-87

	1985			1986			1987		
	Building Construction	Engineering Construction	Total	Building Construction	Engineering Construction	Total	Building Construction	Engineering Construction	Total
					($000)				
Newfoundland	686 110	1 038 241	1 724 351	808 806	719 888	1 528 694	833 741	604 261	1 438 002
Nova Scotia	1 322 732	1 026 096	2 348 828	1 444 845	828 860	2 273 705	1 500 734	732 121	2 233 055
New Brunswick	995 075	452 480	1 447 555	1 040 536	404 255	1 444 791	1 086 815	464 899	1 551 714
Prince Edward Island	181 128	63 494	244 622	221 222	65 319	286 541	207 931	76 574	284 505
Quebec	10 245 635	4 170 063	14 415 698	11 477 930	4 097 549	15 575 479	11 721 159	4 334 030	16 055 189
Ontario	15 858 300	5 250 869	21 109 169	19 361 442	5 407 360	24 768 802	20 446 162	5 908 798	26 354 960
Manitoba	1 607 763	820 117	2 427 880	1 849 696	895 268	2 744 964	1 802 815	1 047 739	2 850 554
Saskatchewan	1 528 847	1 744 874	3 273 721	1 568 662	1 312 843	2 881 505	1 637 169	1 406 674	3 043 843
Alberta	3 888 425	7 387 129	11 275 554	4 024 940	6 078 331	10 103 271	4 210 469	5 899 695	10 110 164
British Columbia, Yukon and Northwest Territories	5 144 972	4 570 814	9 715 786	5 203 520	3 594 742	8 798 262	5 242 760	3 182 774	8 425 534
Canada	41 458 987	26 524 177	67 983 164	47 001 599	23 404 415	70 406 014	48 689 955	23 657 565	72 347 520

Source: Statistics Canada.

[1] Actual expenditures 1985, preliminary actual 1986, intentions 1987.

Chromium

D.R. PHILLIPS

SUMMARY

The major markets for ferrochrome are the stainless and alloyed steel industries. South Africa is the western world's largest producer of chrome ore and ferrochrome, and it accounts for 65% of western world supply.

Due to increased demand for ferrochrome in 1986 and 1987, prices for low carbon ferrochrome increased about 20% and charge chrome about 50% in 1987.

The consumption of ferrochrome in the western world in 1987 increased 7% over 1986, due mainly to increased demand for stainless steel.

Canada imports all of its chromium requirements, mainly in the form of high carbon ferrochrome and charge chrome. In 1987, imports of high carbon ferrochrome doubled while imports of charge chrome increased about 2%.

CANADIAN DEVELOPMENTS

Although there is no chromite ore presently mined in Canada, large resources of chromite exist in the Bird River area of Manitoba and the Eastern Townships of Quebec.

Canada presently has no mine production of chromium but low grade deposits at Bird River, Manitoba and the Eastern Townships in Quebec have attracted new interest. Although the current potential for production appears low, the development of these deposits and upgrading to intermediate or processed chromium products may be worthy of consideration in view of developments in plasma smelting, continued political instability in South Africa and the Philippines, and the scope for low cost production in Canada due to competitive energy costs.

Gateford Resources Inc. and Macamic Resources Inc. expected to complete a drill program by March 1988 on the Reed-Belanger chromite property in the Eastern Townships. They also planned to evaluate the potential to upgrade the ore to ferrochrome.

Chromite mineralization in the Eastern Townships, which was exploited early in the century and during the Second World War, occurs as discontinuous and podiform deposits. Although these small deposits are generally satisfactory in grade and composition, they are not well defined and require further exploration to delineate and quantify the resource potential. The region has not been systematically explored, largely because the mineral rights were held in the past by many independent land owners. This situation changed in 1983 with the enactment of legislation by the provincial government to separate land ownership from mineral rights. Land owners, in order to retain their mineral rights after 1983, had to stake claims on their properties and carry out a specified amount of exploration and development work each year.

The federal and Manitoba governments have initiated studies as part of a federal/provincial Mineral Development Agreement to further assess the economics of developing the Bird River deposit. Their plans called for the completion of the studies in 1988.

The value of imports of chromium products increased from $44 600 000 in 1986 to an estimated $53 400 000 in 1987. Ferrochrome imports, estimated at 48 234 t ($40 084 000) in 1987, exceeded imports in 1986 by 9 189 t. Although the value of ferrochrome imports in 1987 was about double that in 1985, the percentage of ferrochrome imports to total chromium imports, in terms of value, remained about 67% throughout the period 1985-87.

Canada consumes about 21 000 t/y of chromite ore. The major consumers, other than the foundries, are: Canadian Refractories, division of Dresser Canada, Inc.; Didier Refractories Corporation; General Refractories Co. of Canada Ltd.; and

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Kaiser Refractories Company, division of Kaiser Aluminum & Chemical Canada Investment Limited.

Canada's consumption of ferrochromium in 1987 was estimated at 39 000 t. The major consumers were the steel companies. Atlas Steels division of Rio Algom Limited, of Welland, Ontario, is the largest domestic consumer of ferrochromium. It uses both charge chrome and high-carbon ferrochrome.

WORLD DEVELOPMENTS

The consumption of chromium is directly linked to the demand for stainless and specialty steels and for applications in the iron, chemicals and other metallurgical industries. There has been a trend towards reduced chromium consumption in metallurgical applications due to improved melting technology, continuous casting for making specialty steels and the production of metal components to near-net-shape. However, this is expected to have a diminishing impact on the overall consumption of the metal in the next decade.

The demand for chromium increased in 1986 and 1987 in line with the strong recovery in stainless and specialty steel production, which is the main market for chromium, and partly a reaction to the instability in South Africa and the Philippines. It created a tight market in 1987, which resulted in a 52% price increase for charge chrome and a 25% increase for low-carbon ferrochrome.

The increased demand during 1986 and 1987 in the European Economic Community (EEC), the United States and Japan was attributed to increased consumption of chromium in the automotive and other transportation sectors, and in the building sectors. The latter was characterized by substantial plant modernizations, expansions and the building of new facilities.

Mine production in the western world was 7.4 Mt of chrome ore in 1986 and 8.2 Mt in 1987. In terms of contained chromium, these annual figures convert to 2.11 Mt and 2.45 Mt, respectively. The utilization of mine capacity rose from 74% in 1986 to 85% in 1987. In spite of this improvement, aggregate mine production during these two years fell short of western world consumption by about 922 000 t.

Ferrochromium production in the western world was estimated at 1.50 Mt contained chromium in 1987, an increase of 6.1% from 1.41 Mt in 1986. Capacity utilization in 1987 was estimated at 89% compared to 84% in 1986. All of the world's producers of ferrochromium increased their production in 1987 except Brazil, due to power interruptions, and Cuba, due to escalating energy costs.

The production of ferrochromium in the western world has marginally exceeded consumption during the last two years. Although demand was firm and prices increased throughout 1987, producers were limited in their scope to take advantage of the stronger market, partly because of a scarcity of chrome ore and partly because they were approaching their capacity limitations.

The consumption of ferrochrome in the western world in 1986 was 1.36 Mt contained chromium, an increase of 25% over 1985. In 1987, western world consumption rose 8.5% to 1.45 Mt, of which western Europe accounted for 580 000 t, Japan 375 000 t and the United States 275 000 t.

The European Economic Community (EEC) is a major importer of ferrochromium. South Africa is the main supplier and accounts for about 65% of its total imports. Among the EEC countries, West Germany in 1987 took about 32% of all EEC imports.

It was estimated that ferrochromium production in western Europe and Albania was some 625 000 t contained chromium, about equal to their consumption in 1987.

Due to continuing closures of plants in Japan, largely a result of high energy costs, Japan's ferroalloy capacity was estimated at 225 000 t, a decrease of 75 000 t compared to 1986 and an estimated reduction of 140 000 t compared to 1985. The latest closures included Awamura Metal Industry Co. Ltd.'s Uji plant in April 1987 and Japan Metals & Chemicals Co. Ltd.'s Sakata plant in October 1987. It was reported that Japan's ferrochromium producers operated near capacity in 1987.

In the United States, General Motors Corporation at one of its Defiance, Ohio plants installed plasma torch equipment to an existing cupola to achieve improved alloy recovery and melting efficiency. The conversion will permit the charging of unbriquetted machine chips and borings in an operation scheduled to produce 45 t/h of grey iron for the production of cast engine blocks.

The Macalloy Inc. facility at Charleston, South Carolina, that upgraded chrome ore from the U.S. strategic stockpile to ferrochromium in 1987, planned to resume this work in 1988. The upgrading program is part of a barter agreement between the U.S. General Services Administration (GSA) and Macalloy. Macalloy receives tungsten ores and concentrates from the U.S. stockpile as payments. Although the program was initiated in 1982 by a directive from President Reagan as part of a U.S. plan to sustain ferroalloy production for defence purposes, the conversion did not begin until 1984.

An additional upgrading program was authorized for the conversion of stockpiled chromite to 374 000 t of high-carbon ferrochromium.

The United States Trade Representative (USTR) agreed to consider a request from Zimbabwe to give duty-free status to imports of ferrochromium, of a grade not exceeding 3% carbon, for the period July 1988 to June 1989.

Swedechrome AB of Sweden started operating the world's first commercial plasma ferrochrome plant in March 1987. The company's plans called for reaching maximum capacity for the production of high-carbon ferrochrome, estimated at 80 000 t/y, by year end. The technology was developed by SKF Steel AB.

China imports all chrome ore for the production of its ferrochromium. The main suppliers are India and Turkey. It was estimated that China exported about 4 000 t of ferrochromium to Japan in 1987 and consumed the remainder of its output. China's ferrochromium capacity is estimated at 80 000 t/y.

USES

While many minerals contain chromium, chromite is the only commercial ore mineral. The theoretical formula for chromite is $FeCr_2O_4$, although it usually contains several other elements and is represented by the general formula $(FeMn)O\ (CrAlFe)_2O_3$. Traditionally, chromite ores have been classified as metallurgical, chemical and refractory grades, according to the expected industrial end-uses. However, recent technological advances have allowed some degree of interchange in the usage of these three product categories with the result that the classification has become less meaningful. Current nomenclature is based upon chromite composition in addition to end-use. High-chromium ores, defined by high Cr/Fe ratios, are used for making ferrochromium for metallurgical applications. High-iron chromites, previously limited almost entirely to the production of chromium-based chemicals, are now finding growing usage in the production of low quality ferrochromium, refractories and foundry sands. High-aluminum chromites with relatively low iron and silica have application mainly for refractory purposes, primarily in the manufacture of magnesite-chromite and chromite-magnesite brick.

The principal use of chromium ferroalloys is in the production of stainless and heat-resistant steels. Most applications of stainless and heat-resistant steels are in corrosive environments such as petrochemical processing, high-temperature environments such as turbines and furnace parts, and consumer goods such as cutlery and decorative trim. Chromium is added to alloy and tool steels to increase their hardening ability and to improve mechanical properties such as yield strength. Superalloys containing chromium have a high degree of resistance to oxidation and corrosion at elevated temperatures and are used in jet engines, gas turbines and chemical process equipment. Chromium-containing castings are usually used in high-temperature applications.

Increased consumption in the automotive sector has been created by automakers that are asking for packaged deals for extra chrome trim, longer warranties, increased use of stainless steel for catalylic convertors, radiator caps and other control and decorative systems.

Chromium consumption has also increased due to its use in aircraft engines and other aerospace applications, which require chromium superalloys because of their high heat resistance.

The refractory industry uses chromite in the manufacture of refractory bricks, castables, mortars and ramming gun mixes. Chromite castables, mortars and gunning mixes are used for repairs and in the bonding and coating of basic bricks, and in areas where the separation of various types of bricks by a chemically neutral substance is desirable.

Refractories containing both chromite and magnesite are used in furnaces wherever basic slags and dust are encountered, such as in the ferrous and nonferrous metal industries. In the ferrous industry, chromite-magnesite brick is used in basic open hearth and electric furnaces. The phasing-out of open hearth furnaces has led to a decline in the amount of chromite used as a refractory in the steel industry. However, this trend has been offset to a certain extent by an increase in electric furnace production and, overall, chromite refractory consumption in the steel industry is expected to remain stable during the next few years. In the nonferrous metals industry, chromite-magnesite brick is used mainly in converters. The increasing use of oxygen in oxygen-blowing converters, resulting in higher operating temperatures, has changed refractory requirements to a higher magnesite-content brick, thereby decreasing the consumption of chromite in this application. The glass industry uses chromite-magnesite brick in the reheating chambers of glass furnaces, while the kraft paper industry requires a dense chromite brick in recovery furnaces to resist chemical attack by spent liquors.

Chromium chemicals have a wide variety of applications in a number of industries. Most chromium chemicals are produced from sodium dichromate, which is manufactured directly from chemical-grade chromite. Chromium compounds are used as pigments, mordants and dyes in the textile industry; tanning agents for all types of leathers; and for chrome electroplating, anodizing, etching and dipping. Chromium compounds are also used as oxidants and catalysts in the manufacture of various products such as saccharin; in the bleaching and purification of oils, fats and chemicals; and as agents to promote water insolubility of various products such as glues, inks and gels.

OUTLOOK

Western world production, which was estimated at about 8.2 Mt of chrome ore and 2.5 Mt of ferrochromium in 1987, is expected to increase to 8.9 Mt of chrome ore and no change in ferrochromium in 1988. Stocks that were depleted in 1986-87 are expected to be replaced in 1988 and, as this occurs, prices are forecasted to decrease to about $1.21-1.25/kg for charge chrome and $2.00-$2.10/kg for low carbon ferrochromium.

Western world ferrochromium capacity, estimated at 2.8 Mt/y (gross weight) in 1987, is projected to increase by about 90 000 t in 1988. The new capacity is being installed in Sweden, Greece and Turkey. Capacity utilization is expected to remain at about 85% through to 1990.

Western world consumption of ferrochromium is forecasted to decline slightly to about 2.4 Mt/y through to 1990. This sustained level of consumption is attributed to the continued requirement for chromium in the transportation and building sectors of the economy.

A production surplus of about 300 000 t/y of ferrochromium, equivalent to about 10% of annual consumption, could occur from 1988 to 1990. This should be absorbed in the process of rebuilding stocks to more normal levels. Accordingly, the apparent surplus should not have a severe impact on prices.

The current trend of increasing ferrochromium capacity throughout the western world could lead to excess capacity in the long term and result in a substantial decline in prices.

In order to sustain the projected production of ferrochromium to 1990, and to rebuild ore stocks that were reduced in 1986-87, chrome ore production in the western world could rise to about 8.9 Mt in 1988. However, it is expected to revert to 8.2 Mt/y in 1989-90 in response to forecasted demand.

PRICES

Chromium prices published by **Metals Week**

	December 30, 1985	December 28, 1986	December 25 1987
		(US$)	
Chrome ore, dry basis, f.o.b. shipping point			
Transvaal 44% Cr_2O_3, no ratio (per tonne)	40.00-42.00	40.00-42.00	40.00-46.00
Turkish 48% Cr_2O_3, 3:1 ratio (per tonne)	125.00	125.00	115.00
Chromium metal			
Electrolytic 99.1% Cr, f.o.b. shipping point (per kg)	8.27	6.95-8.27	6.95-8.27
		(US¢)	
Ferrochromium, f.o.b. shipping point (per kg Cr content)			
Imported 50-55% charge chrome	93.73-97.02	84.34-85.44	127.89-132.30
Imported 60-65% charge chrome	101.41-103.64	91.51-95.37	132.30-143.33
MW, Imported low carbon, 0.05%C	189.63-191.84	183.02-187.43	220.50-231.53

f.o.b. - Free on board.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
CANADA					
32900-1	Chrome ore	free	free	free	free
34700-1	Chromium metal in lumps, powder, ingots, blocks or bars, and scrap alloy metal containing chromium for use in alloying purposes	free	free	free	free
37506-1	Ferrochromium	free	4.0	5	free
92821-1	Chromium oxides and hydroxides	10	12.5	25	8.0
	With the following exception:				
	Chromic oxide (expires June 30, 1987)	free	free	25	free
	For use in the manufacture of additives for heating, lubricating and fuel oils (expires June 30, 1987)		5		
92821-2	Chromium trioxide (expires June 30, 1987)	free	free	25	free
92838-8	Chromium potassium sulphate	free	free	10	free
92838-9	Chromium sulphate, basic	free	free	10	free

TARIFFS (cont'd)

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
UNITED STATES					
420.98	Chromate and dichromate			2.4	
473.10-20	Chrome colours			3.7	
531.21	Chrome refractory and heat insulating bricks			6.6	
601.15	Chrome ore			free	
606.22	Ferrochromium, not containing over 3% by weight of carbon			3.1	
606.24	Ferrochromium, containing over 3% by weight of carbon			3.1	
632.18	Chromium metal, unwrought and waste and scrap			3.7	
632.86	Chromium alloys, unwrought, 96-99% silicon			9.0	
632.88	Chromium alloys, unwrought, not otherwise specified			5.5	
EUROPEAN ECONOMIC COMMUNITY					
28.21	Chromium oxides and hydroxides			15	
28.38	Sulphates (excluding alums) of chromium			15	
	Alums: chromium potassium bis(sulphate)			13	
28.47	Salts of metallic acids:				
	Chromates			15	
	Dichromates and perchromates			14	
28.56	Carbides of chromium			12	
69.02	Refractory bricks, blocks, tiles and similar refractory construction goods with a basis of chromite			10[1]	
69.03	Other refractory goods with a basis of chromite			12	
73.02	Ferro-alloys:				
	Ferro-chromium			8	
	Ferro-silico-chromium			7	
81.04	Chromium:				
	Unwrought, waste and scrap				
	Chromium alloys containing more than 10% by weight of nickel			free	
	Other			6	
	Other			8	

Sources: Customs Tariff, 1987, Revenue Canada Customs and Excise; Tariff Schedules of the United States Annotated (1987), USITC Publication 1910; U.S. Federal Register Vol. 44, No. 241; Official Journal of the European Communities, Vol. 29, L345, 1986.

[1] Subject to a min. of 1.10 ECU per 100 kg gross.

TABLE 1. CANADA, CHROMIUM IMPORTS, 1985-87

	1985		1986^{P}		1987^{e}	
	(tonnes)	($)	(tonnes)	($)	(tonnes)	($)
Chromium in ores and concentrates						
Philippines	1 581	730 048	3 336	1 435 935	5 412	2 413 000
United States	3 909	1 306 258	5 931	1 728 861	5 931	1 728 000
Cuba	961	445 129	1 040	492 111	1 572	681 000
French Oceania	0	0	1 539	568 960	1 339	554 000
South Africa	2 749	613 794	4 247	1 158 549	1 583	325 000
Turkey	2 124	596 764	0	0	0	0
Total	11 324	3 692 432	16 093	5 384 416	15 837	5 701 000
Ferrochromium (gross weight)						
South Africa	17 236	11 779 347	20 010	14 902 445	27 534	19 539 000
United States	6 525	7 132 374	7 937	7 990 452	13 670	9 008 000
Finland	109	76 526	3 846	2 713 115	2 412	2 196 000
Belgium-Luxembourg	0	0	0	0	2 000	1 816 000
Zimbabwe	0	0	0	0	1 326	2 173 000
Sweden	496	876 744	598	1 030 585	1 291	2 185 000
Greece	0	0	5 000	3 755 883	0	0
Yugoslavia	2 800	2 584 445	1 631	930 554	0	0
Turkey	1 100	847 422	23	20 072	0	0
Total	28 266	23 296 858	39 045	31 343 106	48 234	40 084 000
Chromium sulphates, including basic (gross weight)						
United Kingdom	693	524 904	622	512 207	668	517 000
Germany West	184	160 489	446	414 786	471	466 000
Mexico	0	0	20	12 927	172	120 000
United States	70	83 505	32	28 924	48	65 000
Italy	18	17 640	0	0	0	0
Total	965	786 538	1 120	968 844	1 359	1 168 000
Chromium oxides and hydroxides (gross weight)						
United States	1 108	2 861 534	1 222	3 507 293	1 240	3 389 000
Germany West	404	1 129 759	780	2 135 652	952	1 269 000
United Kingdom	371	916 092	361	982 539	379	1 127 000
U.S.S.R.	20	40 313	20	42 616	156	287 000
Italy	72	138 947	35	84 042	48	120 000
Japan	16	32 302	16	34 368	45	109 000
Belgium-Luxembourg	0	0	25	86 789	23	740 000
Netherlands	0	0	17	36 348	21	510 000
Denmark	0	0	0	0	1	9 000
Chile	18	44 439	0	0	0	0
Total	2 009	5 173 386	2 476	6 909 647	2 865	6 435 000

Source: Statistics Canada.
^{P} Preliminary; ^{e} Estimated.

TABLE 2. CANADA, CHROMIUM TRADE AND CONSUMPTION, 1970, 1975, 1980-87

	Imports		Consumption[2]	
	Chromite[1]	Ferro-chromium[2]	Chromite	Ferro-chromium[3]
	(tonnes)			
1970	27 619	20 814	56 212	28 356
1975	29 663	41 109	36 790	18 417
1980	28 373	41 369	27 900	30 175
1981	47 626	31 573	24 771	29 547
1982	8 053	21 783	15 330	18 393
1983	9 759	32 559	15 682	23 741
1984	11 927	33 092	21 059	28 524
1985	11 324	28 266	17 555	21 856
1986P	16 093	39 045	20 935	33 185
1987[e]	15 837	48 234	23 000	39 045

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Chromium content. [2] Gross weight, available data as reported by consumers.

[3] Includes charge chrome.

P Preliminary; [e] Estimated.

TABLE 3. CANADA, FERROCHROMIUM IMPORTS, 1985-87

Grade	1985[r]	1986P	1987[e]
	(tonnes gross weight)		
High Carbon Ferrochrome (over 2%C)	9 764	14 728	28 754
Low Carbon Ferrochrome (max. 2%)	1 947	3 580	4 330
Charge Chrome	12 941	18 695	12 000
Silicon Ferrochrome	2 402	1 887	2 094
Ferrochrome n.e.s.	1 212	148	246
Total	28 266	39 045	48 234

Sources: Energy, Mines and Resources Canada; Statistics Canada.

P Preliminary; [e] Estimated; [r] Revised; n.e.s. Not elsewhere specified.

TABLE 4. WORLD CHROMITE MINE PRODUCTION 1986 AND 1987, RESERVES 1987, AND FERROCHROMIUM PRODUCTION 1987

Country	Mine Production 1986[e]	Mine Production 1987[e]	Chrome ore Reserves[e] 1987	Ferrochromium Production 1987
	(000 tonnes, gross weight)			
U.S.S.R.	3 300	3 600	142 000	..
Republic of South Africa	3 700	3 950	6 300 000	1 087
Albania	990	1 200	22 000	..
Zimbabwe	600	1 120	830 000	274
Turkey	500	700	80 000	..
India	600	525	66 000	266
Finland	500	480	32 000	150
Philippines	300	400	32 000	30
Brazil	310	290	10 000	143
Sweden	..	..	..	200
Japan	..	..	..	220
Other market economy countries	351	400	25 000	245
Other central economy countries	55	60	4 000	43
World total	8 921	12 725	7 540 000	2 500

Sources: U.S. Bureau of Mines, Mineral Commodity Summaries, 1987; Energy, Mines and Resources Canada.

[e] Estimated; .. Not available.

Clays and Clay Products

M.A. BOUCHER AND D.A. SHAW

Clays are a complex group of industrial minerals which are generally characterized by different mineralogies, occurrences and uses. They are all natural, earthy, fine-grained minerals of secondary origin; they are composed mainly of a group of hydrous aluminum phyllosilicates and may contain iron, alkalis and alkaline earths. The clay minerals, formed by the chemical weathering or alteration of aluminous minerals, are generally classified into four major groups based on detailed chemistry and crystalline structure - the kaolinite group, the smectite group (montmorillonite group of some usages), the clay-mica group and the chlorite group. Clay deposits suitable for the manufacture of ceramic products may include non-clay minerals such as quartz, calcite, dolomite, feldspar, gypsum, iron-bearing minerals and organic matter. The non-clay minerals may or may not be deleterious, depending upon individual amounts present and on the particular application for which the clay is intended.

The commercial value of clays, and of shales that are similar in composition to clays, depend primarily on their physical properties such as plasticity, strength, shrinkage, vitrification range and refractoriness, fired colour, porosity and absorption. Their economic value is also dependent upon their production and transportation costs, the level of competition and the potential for substitution.

USES, TYPE AND CANADIAN DEPOSITS

Common Clays and Shale. Common clays and shales are the principal raw materials available from Canadian deposits for the manufacture of structural clay products. They are found in all parts of Canada, but deposits having excellent drying and firing properties are generally scarce and new deposits are continually being sought.

The clay minerals found in common clays and shales are chiefly illitic or chloritic. The material is sufficiently plastic to permit molding and vitrification at low temperature. Suitable common clays and shales are utilized in the manufacture of structural clay products such as common brick, facing brick, structural tile, partition tile, conduit tile and drain tile. There are no specifically recognized grades of common clay and shale. Specifications are usually based upon the physical and chemical tests of manufactured products. The raw materials utilized in the structural clay industry usually contain up to 35% quartz. If the quartz, together with other nonplastic materials, exceeds this percentage, the plasticity of the clay and the quality of the ware are reduced. If calcite or dolomite is present in sufficient quantities, the clay will fire buff and the fired strength and density will be adversely affected.

Most of the surface deposits of common clays in Canada are the result of continental glaciation and subsequent stream transport. Such Pleistocene deposits are of interest to the ceramic industry and include stoneless marine and lake sediments, reworked glacial till, interglacial clays and floodplain clays.

In eastern Canada, shales are also consumed in large quantities for manufacturing cement near Corner Brook in western Newfoundland, and at Havelock in Kings County, New Brunswick. Common clay from glacial drift is used in Ontario as a source of silica and alumina in the manufacture of grey portland cement at Woodstock and St. Mary's. In Manitoba, shales and clays from glacial Lake Agassiz are extracted to produce lightweight aggregates. In Alberta, local glacial clays from Regina are used for manufacturing cement, lightweight aggregates and mineral wool insulation. In British Columbia, altered volcanic ash is extracted at Barnhartvale for cement, and in Quesnel mainly for use in manufacture of refractory materials. Common clay is also extracted from Sumas Mountain near Abbotsford to produce flue lining, drain pipe, bricks and blocks.

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China Clay (Kaolin). China clay is a white clay composed mainly of kaolinitic minerals formed from weathered igneous rocks. Some deposits occur in sedimentary rocks as tabular lenses and discontinuous beds or in rocks that have been hydrothermally altered. Commercial china clays are beneficiated to improve their whiteness when used as fillers and their whitefiring characteristics when used in ceramics.

China clay is used primarily as a filler and coating material in the paper industry, a raw material in ceramic products, and a filler in rubber and in other products. In the ceramic industry china clay is used as a refractory raw material. In prepared whiteware bodies such as wall tile, sanitaryware, dinnerware, pottery and electrical porcelain, quantities of nepheline syenite, silica, feldspar and talc are used as well.

Several occurrences of kaolin in Canada have attracted attention. In British Columbia, a deposit of clay similar to a secondary kaolin occurs along the Fraser River near Prince George. Another kaolinitic deposit occurs at Lang Bay, near the Powell River. In 1987, Fargo Resources Limited and Brenda Mines Ltd. signed an agreement which will fund a $3 million exploration program for the Lang Bay deposit. Recent drill tests from the deposit indicate 1 Mt of mineable reserves of white filler grade and grey cement grade kaolin. Ceramic grade brown kaolin was also located.

In Saskatchewan, known deposits of sandy kaolinized clay with off-white coloured fines occur near Fir Mountain, Flintoft, Knollys, and Wood Mountain. Ekaton Industries Inc. of Calgary acquired the rights on 18 200 ha of land in southern Saskatchewan to explore for kaolin in 1984. A study at the Wood Mountain kaolin deposit has recently been completed and a commercial process for the production of a premium quality kaolin paper filler has been delineated. More than 200 Mt of kaolin are contained in the deposit and the company is proposing to build a plant with an initial output of 150 000 t/y with capital costs projected to be $27.5 million. In 1987, Ekaton Industries Inc. signed a Letter of Intent with Esso Minerals Canada, a division of Esso Resources Canada Limited, which gives Esso an option to accumulate up to 65% of the property via the funding of a phased development program.

In Manitoba, various kaolinitic-rock deposits have been reported at Arborg, on Deer Island (Punk Island) and Black Island on Lake Winnipeg, and in the northwest at Cross Lake and Pine River; the Swan River Formation has also been investigated as a potential source of kaolin.

In Ontario, extensive deposits of kaolin-silica sand mixtures occur along the Missinaibi and Mattagami rivers. James Bay Kaolin Company, a subsidiary of Carlson Mines Ltd. of Toronto, is developing a kaolin-silica sand deposit near Smooth Rock Falls, Ontario. Proven reserves have been estimated at 63 Mt of ore. A final feasibility study on a 2750 t/d open-pit mine and processing plant was completed by Kilborn Limited in 1987.

In Quebec, kaolin deposits have been actively mined in the past as a coproduct of a silica operation, near St-Rémi-d'Amherst, in Papineau County. Occurrences near Château-Richer in Montmorency County and Point-Comfort in Gatineau County have been studied as potential sources of kaolin for alumina, suitable for aluminous cement and refractories.

Ball Clay. Ball clay is defined as a fine-grained, highly plastic and mainly kaolinitic sedimentary clay. Natural colours range from white to brown, blue, grey and black, usually related to carbonaceous material. Fired colours may be white to offwhite. They are extremely refractory materials and have less alumina and more silica than kaolin. Ball clays occur in beds or lenticular units characterized by complex variations, both vertically and laterally.

Ball clays occurring in Canada are mineralogically similar to high-grade, plastic fire clay and are composed principally of fine-particle kaolinite, quartz and mica. These clays are known to occur in the Whitemud and the Ravenscrag Formations - Willowbunch Member - of southern Saskatchewan. Clay production takes place near Claybank, Eastend, Estevan, Flintoft, Readlyn, Rockglen, Willowbunch and Wood Mountain.

Fire Clay (Refractory Clay). Fire clay is a detrital clay mainly composed of kaolinite with a high content of alumina and silica. The mineral usually occurs in sedimentary rocks as lenticular bodies. These clays may range in plasticity from essentially that of ball clay to nonplastic varieties such as flint clay. They are formed by alteration of aluminous sediments deposited in a swampy environment or following transportation and concentration of clayey material.

Fire clay is used in the manufacture of products requiring high resistance to heat such as fire brick, insulating brick and refractory mortar. The refractory suitability is determined by the pyrometric cone equivalent (PCE) test. Canadian fire clays are used principally for the manufacture of medium- and high-duty fire brick and refractory specialties.

Various grades of good quality fire clay occur in the Whitemud Formation in southern Saskatchewan and on Sumas Mountain in British Columbia. Fire clay, associated with lignite as well as with kaolin-silica sand mixtures, occurs in the James Bay watershed of northern Ontario along the Missinaibi, Abitibi, Moose and Mattagami rivers. At Shubenacadie, Nova Scotia, some seams of clay are sufficiently refractory for medium-duty fire clay. Clay from Musquodoboit, Nova Scotia, has been used by some foundries in the Atlantic provinces, and the properties and extent of this clay were investigated by the Nova Scotia Department of Mines.

Stoneware Clay. Stoneware clays are intermediary between low-grade common clays and the high-grade kaolinitic clays. They are typically a mixture of kaolinitic and micaceous clay minerals. Stoneware clays must be capable of being fully vitrified at a relatively low temperature.

Stoneware clays are used extensively in the manufacture of sewer pipe, flue liners, and facing brick. They are widely used by amateur and studio potters.

The principal source of stoneware clay in Canada is the Whitemud Formation in southern Saskatchewan and southeastern Alberta. Stoneware clays also occur near Abbotsford on Sumas Mountain, at Chimney Creek Bridge, Quesnel and Williams Lake, British Columbia; near Swan River in Manitoba; and in Nova Scotia, at Musquodoboit and at Shubenacadie where it is used principally for manufacture of buff-facing bricks.

Bentonite and Fuller's Earth. Bentonite consists primarily of montmorillonite clay, and is formed from volcanic ash, tuff or glass, other igneous rocks, or from rocks of sedimentary origin. Sodium bentonite has strong swelling properties and possesses a high dry-bonding strength. Calcium bentonite of the non-swelling type usually exhibits greater adsorptive characteristics. Fuller's earth contains mainly smectite-group clay minerals and is very similar to non-swelling bentonite. It is formed by alteration of volcanic ash or by direct chemical precipitation of montmorillonite in shallow marine basins. Fuller's earth is characterized by absorptive properties, catalytic action, bonding power and cation-exchange capacities.

Drilling Mud and Activated Clays. Drilling mud contains about 10% swelling bentonite. Synthetic bentonites may also be used for special muds. The swelling properties of a bentonite used as a drilling mud may be improved by adding soda ash in a drying process to substitute calcium cations with sodium cations. Activated clays are non-swelling bentonites that are acid-leached to remove impurities and to increase the reactive surface and bleaching power. They are used for decolouring mineral oils and as catalysts.

Bentonite, fuller's earth and activated clays are covered in separate sections.

CANADIAN DEVELOPMENTS

Clays. The structure of the clays industry is such that most clays are captively consumed. In particular, common clay, stoneware clay and ball clay are both mined and consumed by lightweight aggregate, cement and mineral wool industries.

In 1987, there was no commercial production of kaolin in Canada. However, three prospective producers located in Ontario, Saskatchewan and British Columbia are actively pursuing mine development for the possible entry into the industry before the end of this decade. Consequently, all Canadian kaolin requirements were supplied by imports in 1987, mainly from Georgia and South Carolina. On a nine month basis in 1987, imports of kaolin declined 13.4% to 197 113 t from the same nine month period in 1986. The value of imports in 1987 was $37.4 million and therefore unit value averaged $190.96.

In Canada, reported consumption of kaolin in 1986 grew 22% to 256 045 t from 1985. The pulp and paper industry accounted for 82.7% of total reported consumption, followed by ceramics, 3.9%; rubber, 3.4%; and paint and varnish, 2.5%.

In 1987, imports of fire clays declined again as a result of lower activity in the refractories industry in general, and a trend toward higher alumina, chrome-alumina, magnesia and zircon refractories which yield improved strength and resistance to wear. Imports of drilling mud and bentonite also declined due mainly to a drop in oil and gas exploration activity.

Clay products. In 1987, some 40 companies accounted for about 95% of the total value of shipments of clay products based on both domestic and imported clays. The value of shipments of clay products from domestic clays rose significantly by 14% to $210.2 million due to a higher level of construction mainly in Ontario and Quebec. In 1987, deliveries of building and face bricks in Canada increased by some 23%. Residential construction accounts for about 90% of total deliveries of building and face bricks in Canada. Higher levels of consumption were reported in residential construction, particularly in Ontario and Quebec. Clay brick producers in the Atlantic provinces were the only ones in Canada where deliveries were substantially lower than in 1986.

National Sewer Pipe started producing face brick at its plant in Oakville during the year.

Canada Brick Co., division of Jannock Limited of Streetsville, Ontario, opened its new face brick plant in Burlington. The construction of the 75 million brick per year manufacturing facility started in 1986 and was completed in October 1987 at a cost of $25 million, creating 35 permanent jobs. The plant will be using the low firing concept and will have the largest capacity for brick in North America when the second phase of construction is completed in two years, doubling the capacity of production at a cost of $10 million. Most of the new production will be used in Ontario but the United States represents a potential market for exports.

Brampton Brick Limited is expected to open a new face brick plant in Ontario in early 1988 to eventually replace its old plant in Brampton.

Refractories. Refractories are produced in Canada by 16 major manufacturers of basic and alumina-silica products. Special refractories such as refractory mineral wool and carbon-compound mortars are also produced.

UNITED STATES DEVELOPMENTS

In the United States, apparent consumption of clays increased in 1986 by 4.7% to 40.1 Mt. Domestic uses of specific clays in 1986 were estimated as follows: kaolin - 44% paper, 6% refractories, and 4% rubber; ball clay - 26% dinnerware and pottery, 17% sanitaryware, and 14% floor and wall tile; fire clay - 50% firebrick and 7% foundry sands; bentonite - 37% drilling mud, 23% foundry sands, and 9% iron ore pelletizing; fuller's earth - 67% absorbent and 12% insecticide dispersant; and common clay - 95% construction materials.

Mine production of clays in 1986 totalled 42.7 Mt, up 4.7% from 1985. Common clay accounted for 67.7% of production, followed by kaolin, 17.5%; bentonite, 5.7%; fuller's earth, 4.9%; and others, 4.2%.

In 1987, Engelhard Corporation, located in McIntyre and Gordon, Georgia, began an $80 million expansion program which will add 270 000 t/y of kaolin to their existing operations capacity. Plans include computerized process control systems and a new calciner. Other U.S. kaolin producer expansions include: Anglo-American Clays Limited, a subsidiary of English China Clays plc, which completed construction of its fourth calciner at its Sandersville, Georgia operations; and Nord Kaolin Company which installed ozone bleaching equipment which will allow the company to expand its reserve position by 8.5 Mt.

OUTLOOK

Structural clay products are used mainly in the residential and non-residential construction industry. In 1988, a decrease of about 5% in shipments to these sectors is forecast.

Demand for refractories in the western world has been decreasing since the late 1970s because of lower steel production, the traditional but highly competitive market for refractories. The strong decline in refractories shipments over most of the current decade is also resulting from improvements in the performance and life of refractories. The increasing usage of water-cooled panels in electric-arc furnaces and hot-metal pre-treatments also reduces the consumption of refractories. The usage of low-grade fire clay and siliceous materials is forecast to decline while refractories made of fired dolomite, magnesia-chrome and magnesia-carbon will be used for more severe operating conditions. Flint clay refractories will be replaced by higher alumina materials such as calcined bauxite and sillimanite minerals with greater performance in ladle linings in particular.

During the next decade the refractory industry in the western world is expected to continue to adjust to falling refractories consumption although a degree of stability has now been attained through the reduction of excess capacity.

Specialization, diversification, and the search for new uses will continue. Traditional markets are likely to assume less importance and refractory consumers will be demanding greater quality products. The field of advanced ceramics is seen as the new challenge for refractories.

OPPORTUNITIES

The trend in the industry is towards the use of high alumina refractories raw materials which command high prices in the range of $175 to $500/t in some cases. High alumina refractory minerals such as andalusite, kyanite and sillimanite offer opportunities in Canada as there are occurrences in several provinces.

PRICE QUOTATIONS FOR BALL CLAY AND KAOLIN

Chemical Marketing Reporter, December 1986-87.

	US$ per short ton	
	1986	1987
Ball clay, f.o.b. Tennessee		
Airfloated, bags, carload	49.00	49.00
Crushed, moisture repellent, bulk carload	24.00	24.00
Kaolin, f.o.b. Georgia		
Dry-ground, airfloated, soft	60.00	38.00
NF powdered, colloidal, 50 lb. bags, 5 000 lb. lots	480.00	551.00
Waterwashed, fully calcined, bags, carload	255.00	255.00
Waterwashed, uncalcined, delaminated paint grade, 1 micron average	182.00	240.00
Uncalcined, bulk, carload		
No. 1 coating	94.00	98.00
No. 2 coating	75.00	76.00
No. 3 coating	73.00	73.00
No. 4 coating	70.00	70.00
filler, general purpose	58.00	58.00

Industrial Minerals, December 1986 quotation (£1.00 = US$1.40-1.60); December 1987 (£1.00 = US$1.60-1.80)

	£ per tonne	
	1986	1987
Ball clay, f.o.b. works		
Air dried, shredded, bulk	15-40	15-40
Refined, noodled, bulk	35-40	35-40
Pulverized, air floated, bagged	50-80	50-80
Kaolin, refined, bulk, f.o.b. works		
Coating clays	75-120	75-120
Filler clays	40-60	40-60
Pottery clays	25-65	25-65

f.o.b. Free on board.

TABLE 1. CANADA, IMPORTS AND EXPORTS OF CLAYS, 1985-87

	1985		1986		(Jan.-Sept.) 1987	
	(tonnes)	($)	(tonnes)	($)	(tonnes)	($)
Imports						
Bentonite						
United States	280 868	14 303 821	228 365	10 153 917	116 240	4 459 405
Greece	64 901	3 707 478	97 853	5 285 740	25 300	1 260 398
West Germany	177	85 083	39	4 765	75	14 079
United Kingdom	72	13 355	36	10 548	18	5 564
France	0	0	5	253	0	0
Total	346 018	18 109 737	326 298	15 455 223	141 633	5 739 446
China clay, ground or unground						
United States	265 133	35 529 807	322 949	45 523 273	196 388	37 384 625
United Kingdom	6 309	992 090	10 244	1 368 709	427	185 713
Italy	0	0	0	0	296	48 497
France	31	6 279	85	11 245	2	449
Total	271 473	36 528 176	333 278	46 903 227	197 113	37 619 284
Fire clay, ground or unground						
United States	42 559	3 070 494	28 568	2 628 871	14 230	1 333 854
United Kingdom	136	52 095	372	151 356	20	5 365
People's Republic of China	1 500	125 688	0	0	0	0
Total	44 195	3 248 277	28 940	2 780 227	14 250	1 339 219
Clays, ground or unground, n.e.s.						
United States	145 120	11 559 519	164 497	12 860 801	87 771	6 263 176
Switzerland	47	6 828	515	16 866	39	11 892
United Kingdom	873	45 516	123	26 934	20	5 260
France	12	1 767	18	2 640	27	2 128
Italy	35	5 365	0	0	0	0
Total	146 087	11 618 995	165 153	12 907 241	87 857	6 282 456
Fullers earth						
United States	4 969	576 573	5 437	451 848	4 106	341 568
Total	4 969	576 573	5 437	451 848	4 106	341 568
Clays and earths, activated						
United States	10 621	11 104 854	9 496	8 799 599	5 086	4 201 121
France	1 703	1 553 895	2 130	1 891 909	1 212	1 039 758
West Germany	505	369 573	553	298 774	247	171 306
United Kingdom	1	1 653	2	12 875	4	4 801
Total	12 830	13 029 975	12 181	11 003 157	6 549	5 416 986
Drilling mud						
United States	6 854	4 361 989	3 245	1 791 305	1 296	739 547
Hungary	0	0	0	0	17	119 436
Netherlands	44	76 514	99	252 632	5	42 378
Japan	70	261 896	12	43 953	0	0
United Kingdom	56	43 755	40	47 239	0	0
France	32	51 20	64	18 225	0	0
Italy	45	149 290	37	128 376	0	0
Total	7 101	4 944 650	3 497	2 281 730	1 318	901 361
Total imports	832 673	88 056 383	874 714	91 782 653	452 826	57 640 320
Exports						
Clays, ground and unground	5 350	2 791 811	1 742	423 449	5 302	762 050

Source: Statistics Canada.
n.e.s. Not elsewhere specified.

TABLE 2. CANADA, VALUE OF PRODUCTION SHIPMENTS OF CLAYS AND CLAY PRODUCTS FROM DOMESTIC CLAY/SHALES SOURCES, 1985-87

	1985	1986	1987[e]
		($000)	
Production from domestic sources, by provinces			
Newfoundland	1 340	1 273	960
Nova Scotia	7 070	7 616	7 730
New Brunswick	4 150	3 026	2 850
Quebec	19 130	29 621	37 250
Ontario	89 130	109 998	130 866
Manitoba	2 160	3 470	3 739
Saskatchewan	3 810	5 700	5 917
Alberta	7 830	10 158	14 063
British Columbia	3 620	8 652	6 833
Total	138 240	179 514	210 208
Production[1] from domestic sources, by products			
Brick - soft and stiff mud process and dry press	116 120		
Drain tile	2 770		
Flue linings	6 220		
Other products[2]	8 850		
Small establishments not reporting detail	4 280		
Total	138 240		

Source: Statistics Canada.
[1] Producers' shipments of clay products including bricks, drain tiles, flue linings. [2] Includes sewer pipes and all potteries. About 85% of the total value of production is accounted for by bricks. Distribution estimated by Energy, Mines and Resources Canada.
[e] Estimated.

TABLE 3. CANADA, REPORTED CONSUMPTION[1] OF CLAYS, BY INDUSTRIES, 1983-86

	1983	1984[2]	1985	1986[P]
		(tonnes)		
China Clay				
Pulp and paper products[3]	97 255	147 234	165 032	211 828
Ceramic products	10 267	9 527	9 468	9 866
Rubber products	6 568	7 225	7 850	8 640
Paint and varnish	6 189	6 065	6 347	6 330
Other products[4]	21 049	21 138	21 141	19 381
Total	141 328	191 189	209 838	256 045
Ball Clay				
Ceramic products misc.	19 749	16 506	15 090	16 162
Refractories	2 578	2 280	2 271	2 589
Other[5]	45 049	44 184[r]	37 815	39 984
Total	67 376	62 970[r]	55 176	58 735
Fire Clay				
Refractory brick, mixes	7 311	8 136	10 680	15 123
Foundries	7 346	8 514	8 247	9 073
Other[6]	21 596	27 383	17 906	38 402
Total	36 253	44 033	36 833	62 598

[1] Reported from EMR survey on the consumption of nonmetallic minerals by Canadian manufacturing plants. [2] Increase in number of paper and paper products and paper pulp companies surveyed. [3] Includes paper and paper products and paper pulp. [4] Includes refractory brick and mixes, fertilisers, glass fibre and glass fibre wool, chemicals, asphalt roofing products, wire and cable and other miscellaneous products. [5] Includes structural clay products, cements, paper and paper products, gypsum products and other miscellaneous products. [6] Includes structural clay products, ceramic products, primary steel, petroleum refining, rubber products, nonferrous smelting and refining and others.
[P] Preliminary; [r] Revised.

TABLE 4. MAJOR CANADIAN MANUFACTURERS OF STRUCTURAL CLAY PRODUCTS AND REFRACTORIES, 1987, BY PROVINCE

Company	Plant Location	Products	Raw Material	Size[1] and Remarks
NEWFOUNDLAND				
Trinity Brick Products Limited	St. John's	building bricks	shale	(B)
NEW BRUNSWICK				
L.E. Shaw Limited	Chipman	facing brick, tiles, drainage and partition	shale	(E)
NOVA SCOTIA				
L.E. Shaw Limited	Lantz	brick, block and tile	common clay, ball clay	(E)
QUEBEC				
Bricade Estrielle Inc.	Westbury	facing brick	common clay	(A)
Canada Brick Co. division of Jannock Limited	Laprairie	building brick and facing	shale	(G) bought from Domtar Inc. in 1985
Citadel Brick Ltd. division of Brampton Brick Limited	Beauport	building brick, drain tile and flue lining	shale	(C) sold to Brampton Brick Limited in 1986
Didier Refractories Corporation	Bécancour	refractory brick and shape, monolithics and mortar	alumina-silica, silica and basic	(E)
Dresser Canada, Inc. Canadian Refractories division	Grenville	refractory brick and shape, monolithics	alumina-silica and basic	(F)
Duquesne Refractories Limited	Dorval	refractory monolithics and mortar	alumina-silica and carbon	(A)
Montreal Terra Cotta Inc.	Deschaillons	building brick, tile and flue lining	shale, common clay	(B)
Quigley Canada Inc.	Lachine	refractory brick and shape, cements	fire clay, basic	(A)
St. Lawrence Brick Co. Limited	Laprairie	building brick	shale	(C)

TABLE 4. (cont'd)

Company	Plant Location	Products	Raw Material	Size[1] and Remarks
ONTARIO				
Amos C. Martin Limited	Parkhill Wallenstein	drain tile	shale	(A)
A.P. Green Refractories (Canada) Ltd.				
Acton division	Acton	refractory brick and shape monolithics, insulation	alumina-silica	(A)
Weston division	Weston		alumina-silica	(C)
Babcock & Wilcox Industries Ltd.	Burlington	refractory brick and shape monolithics, mineral wool	alumina-silica kaolin	(C)
Bimac Canada Metallurgical Limited	Burlington	refractory brick and shape, mineral wool	alumina-silica	(B)
BMI Refractories Inc.	Smithville	refractory brick and shape, mortar	alumina-silica and basic	(A)
Brampton Brick Limited				
Brampton division	Brampton	building brick	shale	(C) new face brick plant under construction
Toronto division	Toronto	building brick	shale	(D)
Canada Brick Co.				
Burlington division	Burlington	building brick	shale	(E)
Burlington division	Burlington	building brick	shale	new plant
F.B. McFarren division	Streetsville	building brick	shale	
Mississauga division	Mississauga	building brick	shale	
Ottawa division	Ottawa	building brick	shale	
Streetsville division	Streetsville	building brick	shale	
Dochart Clay Products Co. Ltd.	Arnprior	tile	common clay	(B)
Dresden Tile Yard (1981) Limited	Dresden	building brick, tile and flue lining	shale	(A)
General Refractories Co. of Canada Ltd.	Smithville	refractory brick and shape, mortar	basic	(D)
George Coultis & Son Limited	Thedford	tile, drain tile	shale	(B)

TABLE 4. (cont'd)

Company	Plant Location	Products	Raw Material	Size[1] and Remarks
ONTARIO (cont'd)				
Glassrock Products of Canada Ltd.	Hamilton	refractory brick and shape, monolithics	alumina-silica and fire-clay	(A)
Halton Ceramics Limited	Burlington	block and tile	common clay and shale	(A)
Hamilton Brick Limited	Hamilton	building brick	shale	(B)
National Refractories & Minerals Inc.	Oakville	refractory monolithics, mortar and insulation	alumina-silica and basic	(C)
National Sewer Pipe Limited	Oakville	flue lining and sewer pipe	shale and fire clay	(B)
	Oakville	face brick		new plant
North American Refractories a division of General Chemical Canada Ltd.	Caledonia	refractory monolithics, mortar and insulation	alumina-silica	(B)
Plibrico (Canada) Limited	Burlington	refractory monolithics, mortar and mineral wool	alumina-silica zircon and basic	(E)
R & I - Ramtite Canada Limited C-E Refractories division	Welland	refractory monolithics and mortar; brick	alumina-silica	(C)
Riverside Refractories Canada Limited	Nanticoke	refractory shapes and mortars	alumina-silica	(A) new plant
MANITOBA				
I.XL Industries Ltd. Red River Brick and Tile division	Lockport	brick and tile	common clay	(E)
SASKATCHEWAN				
A.P. Green Refractories (Canada) Ltd.	Claybank	brick and shape	alumina-silica	(A)
I.XL Industries Ltd. Western Clay Products division	Regina	facing brick, flue lining and sewer-pipe	stoneware clay	(A)
Thunderbrick Limited Estevan Brick division	Estevan	building brick	ball clay	(C)

TABLE 4. (cont'd)

Company	Plant Location	Products	Raw Material	Size[1] and Remarks
ALBERTA				
I.XL Industries Ltd.				
Medicine Hat Brick and Tile division	Medicine Hat	brick, block, tile	common clay	(D)
Medicine Hat Sewer Pipe division	Medicine Hat	sewer pipe and flue lining	common clay	(A)
Northwest Brick and Tile division	Edmonton	building brick	common clay	(B)
Redcliff Pressed Brick division	Redcliff	facing brick and fire brick	common clay	(B)
BRITISH COLUMBIA				
Clayburn Refractories Ltd.	Abbotsford	refractory brick, mortar and monolithics	alumina-silica	(D)
Fairey & Company, Limited	Surrey	refractory brick and shape, monolithics, mortar	alumina-silica	(A)
Sumas Clay Products Ltd.	Sumas	brick, drain tile and flue lining	common clay	(C)

[1] Size keys: (A) up to 25 employees; (B) 25-49; (C) 50-99; (D) 100-199; (E) 200-499; (F) 500-999; (G) over 1000 employees.

TABLE 5. KAOLIN: WORLD PRODUCTION, 1983-85, MAJOR COUNTRIES

	1983	1984	1985[r]
	(000 tonnes)		
United States	6 530	7 210	7 070
United Kingdom	2 720	2 970	3 000
U.S.S.R.[e]	2 630	2 810	2 900
Colombia[1]	760	940	900
Spain[2]	680	840	850
South Korea	680	720	660
Czechoslovakia	660	670	650
India[1]	650[r]	680	630
Brazil[3]	420	490	550
West Germany	410	410	420
Romania	410	410	410
France	340	310	310
Others	2 750	2 620	2 840
Total	19 640	21 180	21 190

Source: U.S. Bureau of Mines, 1985, clays, S. Ampian.

[1] Crude, saleable kaolin. [2] Includes crude and washed kaolin. [3] Processed.

[r] Revised; [e] Estimated.

Coal and Coke

J.A. AYLSWORTH

Canada's coal industry regained some momentum in 1987, recording increases in three important statistics. Overall production, exports and domestic consumption increased during this past year, compensating for unusual declines in these areas in 1986. In addition, preliminary statistics for 1987 indicate that imports will be up over 1986 by about 12%. Signals from several quarters suggest world coal trade is regaining some semblance of balance. If this translates into future price increases, 1987 may be remembered as a precursor of better times for Canada's coal industry.

Based on preliminary statistics for 1987, the volume of production will reach 59.8 Mt, up 2 Mt or 3% over 1986. It should, however, be noted that Statistics Canada has redefined its definition of coal "production", effective January 1987, to equal shipments from a mine/plant plus a mine's own consumption. While this new definition, when applied to 1986 production figures, alters most statistics by a relatively small amount, it does limit exact comparisons with previous years' data.

The majority of the increase in total Canadian production was accounted for by Saskatchewan, where lignite output expanded by 1.6 Mt to meet increased provincial requirements for thermal coal and unexpected demands in Ontario. Production was also up in New Brunswick, Alberta and British Columbia.

During 1987, the Canadian industry continued to react to the changing market realities of the 1980s which resulted from several years of surplus supply and falling prices in international markets. Coal companies continued to reduce costs, improve productivity and look for new market opportunities with both traditional and new customers. Canadian exporters maintained their presence in traditional markets in Japan, South Korea, Brazil and elsewhere and increased their activities in certain markets in Europe, North America and the Mediterranean. In the North American scene western Canadian producers concluded incremental spot sales of thermal and coking coal into markets in Ontario and break through exports of coking coal into Chicago in spite of the lengthy transportation distances involved. The Canadian exports for 1987 are estimated at 26.7 Mt, up 3% over 1986.

The issue of the potential increased use of western Canadian coal in Ontario received additional attention in 1987 with the formation of a federal-provincial committee. The Deputy Prime Minister and Premiers' Action Committee on Western Canadian Low-Sulphur Coal was created in March to identify methods for improving the competitiveness of western Canadian coal for Ontario markets.

An Intergovernmental Secretariat supporting the Action Committee completed a report late in the year identifying a number of initiatives. They focus on improvements in mining capabilities, developing more competitive coal products, identifying alternative transportation systems and removing regulatory impediments. The Action Committee is scheduled to meet in early 1988 to consider implementation options arising out of the Secretariat's Report.

During 1987 acid rain abatement agreements were signed between the federal government and the Governments of Manitoba, Ontario, Quebec, New Brunswick, Prince Edward Island and Newfoundland. These agreements will limit SOx emissions in these jurisdictions to 50% of the 1980 base case levels by 1994.

COAL RESEARCH, DEVELOPMENT AND DEMONSTRATION

Increased use of Canadian coal resources continued to be promoted in other ways in 1987. Work continued on coal research, development and demonstration (R,D&D)

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directed towards technologies that would allow coal to be utilized in a more clean and efficient manner. One of the 1987 highlights was the official opening in August of the 20 MW circulating fluidized bed (CFB) demonstration project at The New Brunswick Electric Power Commission's Chatham generating station.

Circulating fluidized bed combustion technology promotes the expanded use of coal resources by reducing acid gas emissions and allows for more flexibility in coal quality than traditional pulverized coal firing. The Chatham station is the first unit in North America to generate electricity for an electrical grid using CFB technology. The facility is dedicated towards the development and demonstration of CFB technology on a national basis. It is also available for the testing of coals from worldwide sources.

Coal-water fuel technology was advanced during 1987 to the demonstration stage at a 20 MW boiler at the Maritime Electric Company, Limited's Charlottetown generating station. Further developmental work on this new coal product which has advantages in both the transportation and combustion stages, is anticipated in 1988.

PRODUCTION AND MINE DEVELOPMENTS

Coal production in eastern Canada is primarily based on the demands for thermal coal in the provinces of Nova Scotia and New Brunswick. In 1987, output in Nova Scotia is estimated at approximately 2.8 Mt with nearly 90% coming from three mines operated by the federal crown corporation, Cape Breton Development Corporation (CBDC). Three other private sector mines also produce coal for commercial and residential markets in the province. Part of the 1987 output from Nova Scotia was accounted for by the opening of CBDC's Phalen mine. At full production this mine will produce 1.5 Mt of thermal and coking coal for domestic and export markets. During 1987 CBDC also completed a major addition to its Victoria Junction preparation plant doubling the annual throughput capacity from 2 to 4 Mt. These changes helped CBDC increase its domestic sales, while exports remained about equal to 1986s level of nearly 500 000 t. Production of coal in Nova Scotia is forecast to grow by at least 10% in 1988.

Output in Canada's smallest coal producing province, New Brunswick, increased to 550 000 t in 1987. All production comes from the mines of N.B. Coal Limited, which is 90% owned by The New Brunswick Electric Power Commission (NBEPC). The coal is used exclusively for the generation of electricity.

Lignite coal production in Saskatchewan increased to a record 9.9 Mt in 1987 following a decline in 1986. Approximately 80% of the provincial output is sold within the province for the generation of electricity. The majority of the rest is marketed in Ontario and Manitoba to utility and industrial users.

Alberta remained Canada's largest coal producing province in 1987 with an overall output of 25 Mt, up marginally from 1986. Sub-bituminous output increased by nearly 1.2 Mt while bituminous output was down by more than 400 000 t. All the sub-bituminous coal is marketed within the province for the generation of electricity, while approximately 80% of the bituminous coal is exported. Much of the remaining bituminous coal is sold into Ontario markets for the generation of electricity.

One coal mine is currently under development in Alberta. The Genesee mine, jointly owned by Edmonton Power and Fording Coal Limited, is scheduled to begin stripping overburden in early 1989. Production will initially average about 1.5 Mt/y but will eventually increase to 3 Mt sometime in the 1990s when both units of the new Genesee Thermal Generating Station are operating.

Coal production in British Columbia increased marginally in 1987 after an 11% decline in 1986. Production grew by an estimated 850 000 t to 22 Mt based on additional sales in overseas and central Canadian markets. About 95% of the province's annual output is traditionally marketed to overseas customers, with the remainder sold within the province, in Ontario or in the United States.

DOMESTIC COAL UTILIZATION

Preliminary figures suggest that domestic consumption will increase by nearly 6 Mt reaching a record level of 50.5 Mt in 1987. This would represent a 13% increase for 1987, more than compensating for an 8% decline in 1986. Virtually all of this change was accounted for by the increased use of coal by provincial utilities for the generation of electricity.

Consumption of coal for the generation of electricity increased to an estimated 42.1 Mt in 1987, up 16% over the 1986 level of 36.4 Mt. Almost all provinces recorded increased levels of consumption in 1987, reflecting both greater demands for electricity and more extensive reliance on coal consuming facilities.

Coal utilization in the other major coal consuming sectors, the steel industry and the "other" category, remained basically unchanged from 1986. The steel industry consumed approximately 6.3 Mt, up 3% over 1986. Consumption in the "other" category, which includes general industrial, commercial and residential uses, is estimated to have remained unchanged from previous years levels at 2 Mt.

Consumption of thermal coal by Nova Scotia Power Corporation (NSPC) for the generation of electricity totalled 2.3 Mt, up 9% over 1986. Coal supplied about 72% of the electricity generated by the utility during the year. Utilisation of coal was up partly due to the start-up of the Point Tupper station in October. This 150 megawatt (MW) unit was converted from oil to coal firing and will consume up to 400 000 t of coal annually when operating at full capacity. It burned approximately 80 000 t in 1987. Thermal coal consumption will continue to increase in Nova Scotia in the coming years as additional coal fired units are built in the 1990s. The next 150 MW unit addition is scheduled to come on stream in 1991.

Consumption of coking or metallurgical coal in Nova Scotia is estimated to have totalled 240 000 t in 1987, up from 164 000 t in 1986. Coking coal consumption will, however, decline in 1988 as the Sydney Steel Corporation (Sysco) closes down its coke ovens in mid-1988. Enough coke will be stockpiled by then to see Sysco through to the fall of 1989 when a new electric arc furnace will come into service.

Coal consumption increased in New Brunswick by 7% in 1987 to an estimated 500 000 t. All consumption occurs at the generating units of The New Brunswick Electric Power Commission. Forecasts suggest that demand will remain at this current level until at least the mid-1990s when additional generating capacity will be required. New Brunswick coals, along with other fuel options, are being evaluated at the circulating fluidised bed demonstration project at NB Power's Chatham generating unit.

Quebec coal demand is confined to industrial consumers within the "other" category and is forecast to total about 650 000 t in 1987, basically unchanged from 1986 levels.

Coal consumption in Ontario increased by an estimated 22% to about 19.4 Mt in 1987, primarily due to increased consumption of coal for the generation of electricity. Coal consumption by Ontario Hydro increased by 3.3 Mt or 36%, to 12.5 Mt. An increase in the load growth over forecast levels combined with a reduction in electricity generation from hydraulic sources and delays in the return to service of some units at the Pickering Nuclear Generating Station accounted for this unexpected increase.

To help meet the increased level of coal demand in 1987, Ontario Hydro contracted for more than 1 Mt of additional lignite and bituminous low-sulphur western Canadian coal. As a result, western Canadian coal accounted for an estimated 4.5 Mt, or a record 36%, of Ontario Hydro's 12.5 Mt of coal consumption.

Coal requirements by Ontario's steel industry increased by an estimated 2% in 1987 to 6.1 Mt in 1987. Demand by commercial and industrial concerns in the "other" category is estimated to be about equal to the 1986 level of 800 000 t.

Consumption of thermal coal for the generation of electricity in Manitoba rose to an estimated 500 000 t in 1987. This is much above the average consumption for the last few years and considerably up from 1986s consumption of 111 000 t. Low water conditions along with a general increased use of coal for system balancing accounted for the unusually large demand for coal in Manitoba in 1987.

Utilisation of lignite coal for the generation of electricity in Saskatchewan grew by 15% in 1987 to 7.8 Mt due to an increase in the load growth and a reduction in hydro-generated electricity. Consumption is forecast to grow slowly until the early 1990s when a new 300 MW coal fired station is scheduled to enter service. Construction of this station, which will be located near Estevan, is scheduled to begin in 1988. A second 300 MW unit at this station is expected to be added later in the 1990s.

Alberta's coal consumption also grew in 1987 over 1986 due to increases in load growth. Consumption was up 5% to 18.5 Mt, surpassing the 1985 record of 18.1 Mt. Forecasts suggest that coal demand for the generation of electricity will continue to grow in Alberta for the foreseeable future. The next coal fired unit to begin operations will be the first of two 400 MW units at the Genesee Thermal Generating Station near Edmonton. The initial unit is now scheduled for start-up in October 1989. Several other similar sized units are under study or in the planning phase for the 1990s.

Coal consumption in British Columbia is currently confined to industrial consumers in the "other" category and is forecast to total less than 100 000 t in 1987. However, in August the provincial government announced that a Vancouver firm had been awarded a contract to study the feasibility of constructing a 400 to 600 MW capacity coal-fired thermal generating station in the East Kootenay region of the province. The study was to investigate possible sites, coal sources, environmental issues and operating costs. The plant could serve both provincial and U.S. markets, and would be designed to burn British Columbia coal. The study will be completed early in 1988.

IMPORTS

Preliminary statistics indicate that imports of coal in 1987 will total 14.0 Mt, up 7% from 1986. This increase is primarily due to increased imports of about 1 Mt by Ontario Hydro for the generation of electricity. Imports of coking coal and steam coal for "other" coal uses remained basically unchanged from 1986.

OUTLOOK

The Canadian coal industry rebounded in several important respects in 1987. Production and consumption were up after uncharacteristic declines in 1986. Exports were up but only marginally. Towards the end of the year encouraging signals suggested that coal customers were finally realizing that some coal prices have to increase. On the domestic scene, utilities are constructing additional coal fired units, and in Central Canada users are re-evaluating options for increasing the use of both western and eastern Canadian coal.

International coal trade in the 1980s has been conditioned as much by the excess of coal supply as by the sluggish demand. Demand did grow in the 1980s for both coking and thermal coals but production capacity expanded at much faster rates. This forced the prices of much traded coal down to little more than survival levels. The returns to many international producers are now so low that the long term viability of certain export mines is in question. Subsidized production by some new exporters is taking markets away from established producers and is forcing exporters to drop out of certain markets.

These market dynamics are particularly evident in the Asia-Pacific region which is the most accessible market for all but one of Canada's coal exporters. The Japanese steel industry remains the major market in this region. During 1987 this industry appears to have emerged from a difficult period of unprofitability and restructuring following the world recession of the early 1980s. While world steel production will likely only be up marginally in 1987, production by the Japanese and certain other countries of interest to Canadian coal exporters, will be up by more significant amounts.

Forecasts in early 1987, suggesting that Japanese steel output in fiscal year 1987 would be down from the previous year, were revised upwards towards the end of the calendar year. Based on a domestic construction boom in the latter half of the year, Japanese steel production for 1987 is expected to exceed that of 1986. Steel production will also be up in South Korea, Brazil, the United Kingdom, and the United States in 1987. These five markets account for approximately 90% of Canada's coking coal exports.

During late 1987 reports began to appear suggesting that there was a growing realization, at least in the Japanese steel industry, that long term stable coal supply could not be assured at today's prices. Coal producers have been voicing this concern for some time but only the realization of this by customers can bring about the required changes in prices. This will be a slow process, nevertheless, due to the continuing difficult times forecast for many steel industries and the fact that competition for these markets will remain keen. The need for continued restructuring and evolving technological change will be primary concerns for most steel industries for the remainder of this century.

World thermal coal demand will continue to be influenced by levels of economic growth, the price of alternative fuels options, environmental issues, and progress in coal R,D&D. International thermal coal trade has also been affected by considerable excess capacity from extremely low cost producers and from competitors that sell at uneconomic prices to establish market shares. This will continue to hamper traditional producers and has already driven some exporters out of certain markets.

The long term prospects for thermal coal exporters nevertheless remains brighter than for coking coal at least in terms of volume. Prices will, however, continue to be unacceptably low until supply and demand come more into balance and oil prices increase. The success of R,D&D into new coal combustion technologies will also have important long term impacts on thermal coal demand, prices and prospects for growth.

Coal remains an important commodity in Canada as an energy fuel, a raw material input for industry and as a valuable item of international trade. The coal production and consumption industries are forecast to continue to grow at a moderate but steady rate well into the next century. The momentum regained in 1987 should help the industry meet the challenges of the future with renewed optimism.

TABLE 1. SUMMARY OF COAL SUPPLY BY TYPE AND VALUES, 1983-87

	1983		1984		1985		1986		1987P	
	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)
DOMESTIC[1]										
Bituminous										
Nova Scotia	2 986	144 000	3 094	162 000	2 800	158 000	2 695	155 000	2 820	170 700
New Brunswick	558	29 000	564	30 000	560	30 000	490	27 000	550	32 800
Alberta	7 315	371 000	7 630	337 000	7 841	331 000	6 994	262 000	6 880	233 500
British Columbia	11 697	588 000	20 775	1 020 000	22 994	1 106 000	20 359	881 000	21 440	923 800
Total	22 556	1 132 000	32 062	1 549 000	34 195	1 625 000	30 538	1 325 000	31 690	1 360 800
Sub-bituminous										
Alberta	14 464	112 000	15 422	126 000	16 871	146 000	18 225	163 000	18 190	162 700
Lignite										
Saskatchewan	7 760	95 000	9 918	131 000	9 672	135 000	8 281	122 000	9 910	111 500
Total	44 780	1 339 000	57 402	1 806 000	60 738	1 906 000	57 044	1 610 000	59 790	1 635 000
IMPORTED[2]										
Bituminous and anthracite briquettes	14 667	1 031 000	18 352	1 366 000	14 867	1 124 000	13 125	999 000	14 000	..
Total	59 447	2 370 000	75 754	3 172 000	75 605	3 030 000	70 169	2 609 000	73 790	..

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] F.o.b. mines. [2] Value at United States ports of exit.
P Preliminary figures or estimates; .. Not available.

TABLE 2. PRODUCER'S DISPOSITION OF CANADIAN COAL[1], 1986

Destination	Nova Scotia	New Brunswick	Saskatchewan	Alberta	British Columbia	Canada
			(000 tonnes)			
Newfoundland	1	-	-	-	-	1
Prince Edward Island	5	-	-	-	-	5
Nova Scotia	2 404	-	-	-	-	2 404
New Brunswick	-	485	-	-	-	485
Quebec	60	-	-	-	-	60
Ontario	-	-	997	1 336	583	2 916
Manitoba	-	-	253	1	44	298
Saskatchewan	-	-	7 032	1	40	7 073
Alberta	-	-	-	17 826	2	17 828
British Columbia	-	-	-	73	257	330
Total Canada	2 470	485	8 282	19 237	926	31 400
Japan	100	-	-	4 476	12 972	17 548
Others	385	-	10	1 132	6 868	8 395
Total shipments	2 955	485	8 292	24 845	20 766	57 343

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Saleable coal (raw coal, clean coal and middling sales).
- Nil.

TABLE 3. SUMMARY OF COAL SUPPLY-DEMAND, 1976-87

Year	Canada Production				Imports				
	Bituminous	Sub-Bituminous	Lignite	Total	Anthracite	Bituminous	Total Available	Domestic Consumption	Exports
				(million tonnes)					
1976	14.4	6.4	4.7	25.5	0.3	14.3	40.1	28.2	11.9
1977	15.3	7.9	5.5	28.7	0.4	15.0	44.1	30.8	12.4
1978	17.1	8.3	5.1	30.5	0.3	13.8	44.6	31.7	14.0
1979	18.4	9.6	5.0	33.0	0.2	17.3	50.5	34.8	13.7
1980	20.2	10.5	6.0	36.7	0.3	15.5	52.5	37.3	15.3
1981	21.7	11.6	6.8	40.1	0.4	14.4	54.9	38.4	15.7
1982	22.3	13.0	9.5	42.8	0.3	15.5	58.6	41.5	16.0
1983	22.5	14.5	7.8	44.8	0.3	14.4	59.5	43.6	17.0
1984	32.1	15.4	9.9	57.4	0.2	18.1	75.7	48.6	25.1
1985	34.2	16.8	9.7	60.7	0.3	14.6	75.6	48.7	27.4
1986	30.5	18.2	8.3	57.0	0.4	12.7	70.1	44.6	25.9
1987P	31.7	18.2	9.9	59.8	0.4	13.6	73.8	50.5	25.7

Sources: Statistics Canada; Energy, Mines and Resources Canada.
P Preliminary.

TABLE 4. COAL USED BY THERMAL POWER STATIONS IN CANADA, BY PROVINCES, 1968-87

	Nova Scotia	New Brunswick	Ontario	Manitoba	Saskat-chewan	Alberta	Total Canada
				(000 tonnes)			
1968	646	240	5 523	179	1 354	2 128	10 070
1969	676	150	6 424	51	1 123	2 378	10 802
1970	548	113	7 696	503	1 969	2 951	13 780
1971	689	271	8 560	446	1 996	3 653	15 615
1972	663	281	7 599	410	2 145	4 113	15 211
1973	585	193	6 615	386	2 806	4 474	15 059
1974	606	292	6 721	132	2 902	4 771	15 424
1975	571	248	6 834	323	3 251	5 345	16 572
1976	730	207	7 612	979	3 521	5 996	19 045
1977	572	198	8 795	1 113	4 304	7 461	22 443
1978	771	151	9 097	341	4 585	8 029	22 914
1979	644	198	9 901	73	4 956	9 181	24 956
1980	1 052	315	10 779	240	4 972	10 424	27 782
1981	1 126	515	11 460	332	4 935	11 445	29 813
1982	1 300	548	12 484	184	5 897	13 242	33 656
1983	1 400	564	13 025	109	6 625	14 492	36 216
1984	1 974	610	13 413	163	7 925	16 123	40 208
1985	2 235	521	10 985	253	8 290	18 112	40 396
1986	2 137	469	9 172	111	6 786	17 719	36 394
1987	2 330	500	12 500	500	7 775	18 556	42 161

Sources: Statistics Canada; Energy, Mines and Resources Canada.

TABLE 5. SUMMARY OF COAL DEMAND, 1982-87

	1982	1983	1984	1985	1986	1987P
			(000 tonnes)			
DEMAND						
Thermal Electric						
Canadian	24 033	26 748	29 935	32 563	30 035	34 160
Imported	9 623	9 468	10 273	7 833	6 359	8 000
Total	33 656	36 216	40 208	40 396	36 394	42 160
Metallurgical						
Canadian	229	102	-	52	243	300
Imported	5 347	5 481	6 542	6 210	5 891	6 040
Total	5 576	5 583	6 542	6 262	6 134	6 340
General Industry						
Canadian	1 260	847	813	582	655	700
Imported	986	1 003	1 136	1 416	1 375	1 300
Total	2 246	1 850	1 949	1 998	2 030	2 000
Exports						
Canadian	16 004	17 011	25 138	27 378	25 943	26 740
Total						
Canadian	41 526	44 708	55 886	60 575	56 876	60 860
Imported	15 956	15 952	17 951	15 459	13 625	14 000
Grand Total	57 482	60 660	73 837	76 034	70 501	75 900

Sources: Statistics Canada; Energy, Mines and Resources Canada.
- Nil; P Preliminary.

TABLE 6. EXPORTS OF CANADIAN COAL BY DESTINATION

	Jan.-Nov. 1987	Jan.-Nov. 1986
Belgium	-	123
Brazil	1 100	1 130
Chile	153	177
Denmark	302	278
France	599	929
Hong Kong	313	249
Japan	15 354	16 567
Pakistan	189	190
Portugal	207	35
South Korea	3 471	2 846
Taiwan	565	549
United Kingdom	334	328
United States	758	328
West Germany	211	178
Mexico	-	51
Netherlands	223	111
Philippines	-	60
Sweden	352	280
Yugoslavia	-	61
Turkey	53	-
Italy	21	-
Total	24 205	24 470

Source: Statistics Canada and Energy, Mines and Resources Canada joint survey, Coal.
- Nil.

TABLE 7. CANADA, COAL PRODUCTION, IMPORTS, EXPORTS AND CONSUMPTION, 1982-87

	Production	Imports	Exports	Domestic Consumption
	(000 tonnes)			
1982	42 811	15 773	16 004	41 478
1983	44 780	14 667	17 011	43 649
1984	57 402	18 352	25 138	48 699
1985	60 738	14 867	27 378	48 656
1986	57 044	13 125	25 943	44 558
1987P	59 790	14 000	26 740	50 500

Sources: Statistics Canada; Energy, Mines and Resources Canada.
P Preliminary figures or estimates.

TABLE 8. CANADA, COKE PRODUCTION AND TRADE, 1976-86

	Production		Imports		Exports	
	Coal	Petroleum	Coal	Petroleum	Coal	Petroleum
	(tonnes)					
1976	5 289 185	678 432	287 249	591 859	169 895	136 970
1977	4 845 066	921 363	382 827	986 678	198 727	157 191
1978	4 967 664	1 014 076	553 349	973 985	217 595	134 762
1979	5 775 141	1 105 433	520 534	980 657	228 601	125 416
1980	5 249 744	1 156 444	626 923	908 322	319 554	150 200
1981	4 659 007	1 098 397	653 645	935 929	190 879	200 149
1982	3 999 117	1 083 129	453 915	650 810	129 793	104 897
1983	4 120 002	986 730	576 649	759 954	45 606	65 323
1984	4 900 478	1 072 983	660 257	886 734	116 226	55 300
1985	4 683 770	1 099 808	369 224	866 530	46 882	45 968
1986	4 552 532	765 867	432 730	941 314	108 787	46 554

Cobalt

R. TELEWIAK

Cobalt markets were relatively flat in 1987. Consumption was little changed from the 19 000 t recorded in 1986 and prices, in contrast to the volatility of 1986, were quite stable during the year.

Demand from the superalloy sector, which accounts for about one third of the total, was again relatively strong. This was led by the manufacture of new commercial and military jet engines, as well as normal replacement of jet engine parts, primarily turbine blades.

CANADIAN DEVELOPMENTS

The two mine producers of cobalt, INCO Limited and Falconbridge Limited, recover cobalt as a by-product of nickel-copper production. INCO operates mines at Sudbury, Ontario and Thompson, Manitoba. Falconbridge's mines are also at Sudbury. Developments at these mines during 1987 are described in detail in the Nickel chapter.

At Port Colborne, Ontario, INCO operated its cobalt refinery at its capacity of 1 400 t/y of electrolytic cobalt rounds. The refinery was opened in 1983 and high quality cobalt metal is produced for use primarily in the superalloy sector.

Cobalt feedstock supply for Sherritt Gordon Mines Limited's refinery at Fort Saskatchewan, Alberta, remained about the same as in 1986. Sherritt Gordon toll-refines cobalt from several domestic and foreign sources and also custom refines cobalt. Sherritt Gordon made some modifications to the refinery in 1987, to increase the production of cobalt powders.

Geddes Resources Limited started an adit at its Windy Craggy copper-cobalt-gold deposit in northwestern British Columbia. By year-end, the adit had been advanced 1 300 m. The mineralized zone is expected to be intersected at 1 700 m and then, concurrent with an underground drilling program, some exploratory drifts will be driven. The focus of the program is the zone with the highest gold values but the adit is being driven through the zone with highest cobalt concentrations. The deposit is reported to contain 318 Mt of mineralization averaging 1.5% copper, 0.08% cobalt plus gold values. Underground sampling is expected to start in March 1988.

WORLD DEVELOPMENTS

Producers continued to operate at roughly 60% of capacity. Zaire, which is the largest producer, operated at about one half of its capacity. Zambia, the second largest producer, reduced its production compared with that in 1986 due to weak market conditions.

In Finland, Outokumpu Oy suspended briquette and powder production on April 13 at its Kokkola refinery, due to weak international cobalt market conditions. Initially the shutdown was temporary but when cobalt markets did not improve, the company announced that the suspension would be permanent. The company is continuing with the production of cobalt chemicals and certain specialty powders. This leaves two producers of standard cobalt powder in the western world, Sherritt Gordon in Alberta and Impala Platinum Limited of South Africa.

Nonoc Mining & Industrial Corporation in the Philippines did not operate its nickel mine from which by-product cobalt is produced. The mine had operated intermittently in 1986 but was then closed due to weak nickel markets. With the strengthening of nickel prices during the latter part of 1987, some interest was shown in reexamining the economic viability of the operation. It is believed that capital expenditures of more than $100 million would be required if production is to be resumed.

Nonoc had been shipping its nickel-cobalt mixed sulphide to Sumitomo Metal Mining Co. Ltd. in Japan for refining.

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In Brazil, Companhia Niquel Tocantins, proceeded with the installation of a cobalt refinery at its complex in the state of Sao Paulo, which will process the cobalt obtained as a by-product of its nickel production. Initial cobalt production is expected to be 300 t/y.

PRICES

In November 1986, Zambia and Zaire moved to stabilize the cobalt market by establishing a producer price of US$7.00/lb. Cobalt prices in early 1986 had been close to $11.70/lb., which was the price that Zaire and Zambia had instituted in 1983, but subsequently had fallen below $4.00/lb. in September 1986 due to discounting by producers. The new list prices proved to be more effective, however, and cobalt prices were relatively stable throughout 1987. Producers sold on the basis of the producer price minus a discount of about 5 to 11% depending primarily on volume of sales.

USES

One of the major uses for cobalt is in superalloys where it improves the strength, wear and corrosion resistance characteristics of the alloys at elevated temperatures. The major use of cobalt-base superalloys is in turbine blades for aircraft jet engines and gas turbines for pipeline compressors. Cobalt-based superalloys normally contain 45% or more cobalt, while nickel and iron based superalloys contain 8 to 20% cobalt.

Although the demand for cobalt in the production of magnets has been declining in recent years, this is still an important use for cobalt. Consumption of cobalt in this sector is now less than one half of the 1970 level.

Cobalt-based alloys are used in applications where difficult cutting is involved and high abrasion resistance qualities are required. The most important group of cobalt-base alloys is the stellite group, containing cobalt, tungsten, chromium and molybdenum as principal constituents. Hardfacing or coating of tools with cobalt alloys provides greater resistance to abrasion, heat, impact and corrosion.

Cobalt metal powder is used as a binder in making cemented tungsten carbides for heavy-duty and high-speed cutting tools.

As a chemical product, cobalt oxide is an important additive in paint, glass, and ceramics. Cobalt is also used to promote the adherence of enamel to steel for applications such as appliances, and steel to rubber for the construction of steel-belted tires. A cobalt-molybdenum-alumina compound is used as a catalyst in hydrogenation of oils and in petroleum desulphurization.

OUTLOOK

Over the long term, cobalt consumption is expected to increase at an annual rate of 1 to 2%. The price volatility in the late 1970s and early 1980s, along with some concern over potential security of supply, has resulted in considerable substitution away from cobalt in certain uses and is a major factor in the forecast of a relatively modest increase.

Major consuming countries have expended considerable resources to find substitutes for cobalt in key applications. These programs have reduced the amount of cobalt used or eliminated it completely in certain applications. As an example, Pratt & Whitney Group of the United States has developed a jet engine combustor which consists of a nickel alloy, to replace a cobalt alloy. A heat resistant ceramic coating reportedly makes the nickel alloy at least as durable as the cobalt one.

Zaire and Zambia are the two largest producers in the world, accounting for about two thirds of cobalt capacity. The strategies which these two producers pursue, along with other possible events in these countries, will have a major impact upon supply and consequently on prices.

TABLE 1. CANADA, PRODUCTION AND TRADE, 1985-87, AND CONSUMPTION, 1984-86

	1985		1986		1987P	
	(kilograms)	($)	(kilograms)	($)	(kilograms)	($)
Production[1] (all forms)						
Ontario	1 731 269	60 433 575	2 011 639	40 322 763	2 484 500	47 034 000
Manitoba	335 546	11 526 462	285 537	6 300 654	392 600	7 432 310
Total	2 066 815	71 960 037	2 297 178	46 623 357	2 877 100	54 466 380
Exports					**(Jan.-Sept.)**	
Cobalt metal						
United States	1 300 047	30 661 397	1 353 701	23 949 693	1 045 342	17 050 642
United Kingdom	113 000	630 280	183 147	1 304 779	218 600	2 349 331
Belgium-Luxembourg	125 000	697 211	128 800	713 948	76 000	423 909
Australia	6 253	224 043	74 007	2 221 319	4 610	130 284
Other countries	7 129	597 790	66 290	2 179 290	34 671	1 465 376
Total	1 551 429	32 803 592	1 805 145	30 369 029	1 379 223	21 419 542
Cobalt oxides and hydroxides[2]						
United Kingdom	267 000	7 436 000	374 000	9 859 168	300 000	4 525 580
Total	267 000	7 436 000	374 000	9 859 168	300 000	4 525 580
Consumption[3]	1984		1985		1986P	
Cobalt contained in:						
Cobalt metal	85 736		70 853		71 274	
Cobalt oxide	6 283		10 297		10 675	
Cobalt salts	20 953		20 017		14 223	
Total	112 972	..	101 167	..	96 172	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Production (cobalt content) from domestic ores. [2] Gross weight. [3] Available data reported by consumers.
P Preliminary; .. Not available.

TABLE 2. CANADA, COBALT PRODUCTION, TRADE AND CONSUMPTION, 1970, 1975 AND 1980-86

		Exports		Imports		
	Production[1]	Cobalt metal	Cobalt oxides and hydroxides	Cobalt ores[2]	Cobalt oxides and hydroxides[3]	Consumption[4]
			(tonnes)			
1970	2 069	381	837	..	..	148
1975	1 354	431	561	..	..	123
1980	2 118	325	1 091	2	26	105
1981	2 080	677	601	24	20	101
1982	1 274	585	230	2	30	81
1983	1 410	885	192	45	30	101
1984	2 123	1 487	374	-	-	113
1985	2 067	1 551	267	-	-	101
1986	2 297	1 805	374	-	-	96P

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Production from domestic ores and cobalt content of intermediate products exported, including cobalt content of INCO Limited and Falconbridge Limited shipments to overseas refineries. [2] Cobalt content. [3] Gross weight. [4] Consumption of cobalt in metal, oxides and salts.

P Preliminary; .. Not available; - Nil.

TABLE 3. WORLD PRODUCTION OF COBALT, 1982-86

	1982	1983	1984	1985P	1986e
			(tonnes)		
Zaire	11 302	11 301	18 008	20 003	20 003
Zambia	3 251	3 199	4 620	5 800	5 761
Canada	1 404	1 158	2 123	2 067	2 297
Australia	1 479	1 179	1 079	830	880
Finland	1 036	1 035	950	953	953
Cuba	1 497	1 621	1 397	1 420	1 406
U.S.S.R.	2 268	2 358	2 585	2 722	2 812
Other	2 282	1 437	1 566	2 582	1 846
Total	24 518	23 288	32 328	36 377	35 958

Source: U.S. Bureau of Mines; Energy, Mines and Resources Canada.

P Preliminary; e Estimate.

Columbium (Niobium)

D.G. FONG

The 1987 western world production of columbium, at 15 000 t of contained columbium pentoxide (Cb_2O_5), was down by 29% from 1986. This large decline was due to cutbacks in Canada and Brazil, a result of inventory build-ups at producers in these two countries.

The demand for columbium in 1987 decreased by 7%. Higher consumption that was related to a strong steel market in North America was more than offset by weaker demand in Europe and Japan, especially during the first half of the year. A slowdown in the manufacture of large diameter pipe and heavy plate in Europe and Japan was a major factor.

Prices during 1987 remained stable for standard columbium products. Although prices are expected to stay near their current quotations in the near-term, there is a risk of deterioration as additional new capacity coming on-stream will further exacerbate the current excess production capacity. Furthermore, markets are expected to stagnate, particularly in view of advancements in steelmaking technology and increasing competition from substitutes such as ceramics.

CANADIAN DEVELOPMENTS

Columbium is produced in Canada at the Niobec mine, which is located at St.-Honoré, Quebec. Production at Niobec in 1987 was 2 630 t of contained Cb_2O_5, a decline of 10% compared to 1986. The mine had a 9-week shutdown in late August due to high inventories and weak demand, especially in Europe during the first half of 1987. Prior to the shutdown, inventories reached 726 t, which represented a 2 to 3 month supply. The mine was reopened on November 2 and production soon returned to its normal level of operation.

The Niobec mine is jointly owned by Cambior inc. and Teck Corporation; each has a 50% interest. Cambior, which is 31.8% owned by the Quebec government, is responsible for marketing the mine output.

Niobec was the only major supplier of pyrochlore concentrate in the world. The Niobec product is sold under long-term contracts through agents such as Continental Alloys SA in Europe, Metallurg Inc. in the United States and Mitsui & Co., Ltd. in Japan.

An Order-in-Council was passed on November 19, 1987, to provide duty-free entry for ferrocolumbium made from Canadian columbium ores and concentrates. Prior to the change, ferrocolumbium imports were subject to a 4% duty, with the exception of those entering Canada under the General Preferential Tariff which are duty-free. Currently, there is no production of ferrocolumbium in Canada.

Hecla Mining Company of Canada Ltd. planned to spend US$2.5 million to continue development on the Highwood Resources Ltd. Thor Lake project. The Thor Lake deposits, located about 100 km southeast of Yellowknife in the Northwest Territories, are multimineral occurrences with berylium, yttrium, columbium, tantalum, and rare earth elements as the major economic metals.

In September 1986, Highwood Resources and Hecla Mining signed an agreement to jointly develop the Thor Lake property. The agreement called for Hecla to complete detailed feasibility and marketing studies by February 1988 and to reimburse Highwood Resources $8 million for its prior expenses in order for it to earn a 50% interest in the project. By year-end, Hecla was reported to have completed the market research and had a pilot operation under way in Denver, Colorado. The additional money approved for this project will go to the refinement of the chemical extraction process and market development. Hecla has indicated it would develop a schedule for commercial production by mid-February 1988.

WORLD DEVELOPMENTS

Due to the weaker demand for columbium during 1986 and the first half of 1987, and the accumulation of inventories, the world's

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leading columbium producers operated substantially below capacity during the year. In Brazil, the Araxá mine of Companhia Brasileira de Metalurgia e Mineração S.A. (CBMM), the world's dominant producer, was reported at 50% capacity and Mineração Catalao de Goias S.A. was producing at 75% capacity. At capacity, CBMM produces 25 000 t/y and Catalao 2 720 t/y Cb_2O_5 contained in concentrates.

CBMM, which supplies about 70% of the world's needs, is 52.65% owned by Metropolitana de Comercio e Participacoes of Brazil and 47% by Molycorp, Inc. of the United States. It operates entirely under Brazilian management. Besides producing a standard grade ferrocolumbium, which represents over 90% of its total output, CBMM also produces a wide range of high purity columbium products including vacuum grade ferrocolumbium, nickel-columbium, columbium metal, and high purity and optical grade columbium oxides.

CBMM received approval from the Brazilian government late in 1986 to construct a 40 t/y columbium metal plant, which is expected to come on stream in 1990. The approval of the US$6.2 million project will enable the company to buy imported equipment and a special furnace. The company currently produces columbium metal in São Paulo under an agreement with the Ministry of Industry and Commerce, and small shipments have been made to the United States for market testing.

Approximately 30% of CBMM's production is sold through Niobium Products Company Ltd., its subsidiary, with offices in Pittsburg and Düsseldorf. Its standard grade ferrocolumbium is also sold through firms such as Molycorp, Inc. and Shieldalloy Corporation in the United States and Canada, Klöeckner and Co. and Gesellschaft für Elektrometallurgie mbH in Europe, London & Scandinavian Metallurgical Co. Ltd. in the United Kingdom, AB Ferrolegeringar in Scandinavia and Nissho Iwai Corporation in Japan.

Mamore Mineração e Metalurgia SA, a unit of the Paranapanema Group, was to begin trial production of columbium and tantalum oxides at year-end at its Pitinga tin mine in the Amazon region. The new processing plant, with an annual production capacity of 970 t/y of oxides, is designed to recover oxides of columbium and tantalum in a ratio of 10:1. These oxides will be produced as by-products of tin mining. Paranapanema is the largest tin producer in Brazil.

In the United States, the U.S. Trade Representative office held a hearing in October on whether columbium oxide from Brazil should continue to be exempted from tariff under the Generalized System of Preferences. Teledyne Wah Chang Albany of Teledyne, Inc., Albany, Oregon, the U.S. columbium producer, petitioned for a review of the Brazilian entitlement to the duty-free status. Teledyne claimed that recent levels of imports contravened U.S. law, which states that if an import of a beneficiary nation exceeds 50% of total imports, it should be excluded from duty-free status. Teledyne claimed that the Brazilian material accounted for a majority of U.S. imports of columbium oxides. A decision on this case is expected to be made by April 1, 1988.

USES

The steel industry is the largest consumer of columbium, which is used in the form of ferrocolumbium as an additive agent in high-strength low-alloy (HSLA) steels, stainless steels and heat-resisting steels. Although the quantity of contained columbium may be as low as 0.02%, the yield strength and mechanical properties of the resulting steel are significantly improved. These characteristics are particularly important in applications such as large-diameter pipelines, automotive components, structural applications and drilling platforms.

High-purity columbium pentoxide is used mainly in superalloys for turbine and jet engines, which have traditionally been the second largest use after steels. A columbium addition to the cobalt and nickel based superalloys improves the high temperature characteristics of these alloys. In addition, columbium-based alloys containing tantalum, tungsten and zirconium are being used in the aeronautic and nuclear industries.

In the manufacture of high-alloy and stainless steels, columbium is used to impart resistance to corrosion at elevated temperatures, a property of particular importance in petroleum processing plants, heat exchangers for severe chemical environments and acid pressure vessels.

One of the important properties of pure columbium is its superior conductivity compared with other metals. Superconductivity is the loss of all resistance to electrical current at temperatures near absolute zero. This special property has allowed the construction of powerful electrical generators, which are much more efficient than conventional generators with copper wire windings. Also, because of the powerful magnetic field created by the superconductors, columbium is used extensively in the construction of nuclear magnetic imaging (NMI). Many other potential applications in electrical devices are being developed, including new types of motors, ship engines, electric generators and switch elements for computers.

Special high-purity columbium pentoxide is produced for optical applications. Additions of columbium pentoxide to optical glass give a high refractive index and thereby allow production of thin lenses for eyeglasses. This characteristic, along with others such as lightweight and durability, enable such lenses to be competitive with plastic lenses.

PRICES

Quoted prices for standard grade columbium products in 1987 remained unchanged while the prices for high-purity products were generally lower. Metals Week showed the Niobec concentrate price at US$5.73/kg of contained Cb_2O_5. Prices quoted by CBMM were US$12.35/kg of contained Cb for standard grade ferrocolumbium, US$33.60-$34.20/kg of contained Cb for vacuum grade ferrocolumbium, US$35.80-$36.40/kg for nickel columbium and US$66-$73/kg for columbium metal. Prices for high-purity oxide were unchanged at US$14/kg for the catalytic grade and US$45-$60/kg for the optical grade.

OUTLOOK

The growth in global consumption of columbium has been adjusted downwards to 2% per year in view of the following factors. Firstly, there is a lower requirement for columbium steel in the energy sector because of a slowdown in large diameter pipeline construction. Secondly, miniaturization and downsizing, particularly in the automotive industry where columbium has been used for strengthening steels, has stabilized. Thirdly, the expectations for vigorous growth in high-purity columbium superconductors did not materialize and new applications such as catalysts and new carbides have not yet advanced beyond the research and development stage.

In regards to superconductors, the application of magnetic resonance imaging (MRI) remained at a low level despite being a much more powerful tool for medical diagnosis compared with X-Ray machines. The main reason is the high capital cost of MRI. At a cost of US$3 million for each machine, this situation is not expected to change significantly within the next decade. Also, the proposed construction of a US$6 billion superconducting super collider in the United States, 80 km in circumference, is now considered unlikely for the near future. Even if the super collider were to be built, columbium superconductors, which have to be operated in liquid helium, will face tough competition from ceramic superconductors that can operate at the temperature of liquid nitrogen.

On the supply side, there will be excess capacity well into the next decade. Although Brazil, with its abundant proven reserves and newly found resources, will continue to be the dominant source for centuries to come, other countries such as Canada, Zaire, China, the Soviet Union and Greenland could develop into strong alternative suppliers to it.

China could emerge in the future as an important source of columbium supplies. Chinese columbium has been produced historically from a number of small tantalite-columbite and tin operations. More recent work has been focused on the recovery of ferrocolumbium from columbium-rich iron ores. The successful exploitation of this source could result in significant new amounts of ferrocolumbium on the export market, thereby reducing the western world's reliance on Brazil.

PRICES

Prices as quoted in Metals Week in December 1986 and 1987, U.S. currency.

	1986	1987
	($)	
Columbium ore		
Columbite, per kg of pentoxide, c.i.f. U.S. ports[1]	4.41-5.51	4.41-5.51
Canadian pyrochlore, per kg, f.o.b. mine	5.73	5.73
Ferrocolumbium, per kg Cb, f.o.b. shipping point		
Low alloy	12.48	12.35
High purity alloy	37.48-38.58	37.48-38.58
Columbium metal, per kg 99.5-99.8%, f.a.s. shipping point		
Reactor ingot	66.14-72.75	66.14-72.75
Reactor powder	77.16-99.21	77.16-99.21

[1] The range reflects variations in the ratio of columbium pentoxide (Cb_2O_5) to tantalum pentoxide (Ta_2O_5).
c.i.f. - Cost, insurance and freight; f.o.b. - Free on board; f.a.s. - Free alongside ship.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
CANADA					
32900-1	Columbium and tantalum ores and concentrates	free	free	free	free
35120-1	Columbium (niobium) and tantalum metal and alloys in powder, pellets, scrap, ingots, sheets, plates, strips, bars, rods, tubing or wire for use in Canadian manufactures (expires June 30, 1987)	free	free	25	free
37506-1	Ferrocolumbium, ferrotantalum, ferro-tantalum-columbium	free	4.4	5	free
UNITED STATES					
601.21	Columbium ore		free		
628.15	Columbium metal, unwrought, other than alloys; and waste and scrap		3.7		
628.17	Columbium, unwrought alloys		4.9		
628.20	Columbium metal, wrought		5.5		

Sources: The Customs Tariff, 1987, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1987), USITC Publication 1910; U.S. Federal Register, Vol. 44, No. 241.

TABLE 1. CANADA, COLUMBIUM (NIOBIUM) PRODUCTION, TRADE AND CONSUMPTION, 1970, 1975 AND 1980-87

	Production[1]	Imports		Exports[2]	Consumption[4]
		Primary Forms and Fabricated Metals			
	Cb_2O_5 Content	Columbium	Columbium Alloys	Columbium Ores and Concentrates to United States	Ferrocolumbium and Ferro-tantalum-columbium (Cb and Ta-Cb Content)
			(kilograms)		
1970	2 129 271	..	..	576 227	132 449
1975	1 661 567	..	..	9 682	215 910
1980	2 462 798	877	156	655 721	486 251
1981	2 740 736	913	303	419 865	455 500
1982	3 086 000	805	59	291 193	356 000
1983	1 744 722	967	396	543 599	359 000
1984	2 766 805	1 045	236	1 132 892	482 000
1985	2 928 700	889	499	1 279 764	447 000
1986	2 911 580	706	963	1 292 623	438 000P
1987P	2 630 000	3 128[3]	6 302[3]	..	..

Sources: Energy, Mines and Resources Canada; Statistics Canada; U.S. Department of Commerce.

[1] Producers' shipments of columbium ores and concentrates and primary products, Cb_2O_5 content. [2] From U.S. Department of Commerce, Imports of Merchandise for Consumption, Report FT 135. Quantities in gross weight of material. [3] January to October 1987.

[4] Available data as reported by consumers.

P Preliminary; .. Not available.

Copper

W. McCUTCHEON

Canadian copper producers' financial difficulties of recent years were alleviated by the rise in copper prices in late 1987.

Canadian production of recoverable copper in concentrates is estimated at 740 000 tonnes (t) in 1987 and at 745 000 t in 1988 although 1988 production could increase if prices were to remain high. Canadian refined production is estimated at 495 000 t in 1987 and 545 000 t in 1988. Canadian shipments of recoverable copper in all concentrates processed domestically and of payable copper in concentrates exported are estimated at 767 000 t in 1987.

. Prices on the London Metal Exchange (LME) opened 1987 at US61¢/lb., reached $1.00/lb. in November, ended the year at $1.45/lb. and averaged 80.1¢ (see Figure 1). Combined LME and Commodities Exchange, Inc. (COMEX) stocks declined by 191 000 t to less than 70 000 t at year end (see Figure 2).

Canada and the United States agreed in principle on the elements of a Free Trade Agreement, signed January 2, 1988. Upon ratification by both countries, the agreement will come into force January 1, 1989, and will be fully implemented over a ten-year period. A dispute settling mechanism and elimination of tariffs are included.

CANADIAN DEVELOPMENTS

Copper mines operating in Canada are listed in the table on Nonferrous Metal Mines following the last commodity chapter of the yearbook.

In **Quebec**, an April fire at Noranda Inc.'s Division Mines Gaspé underground operation caused extensive damage, resulting in indefinite suspension of the mining operations. The company estimates that over a year of rehabilitation and reconstruction would be required prior to resumption of mining. The smelter continued operations through the year, processing imported concentrates. In October, Gaspé received 7 000 t of high-grade development ore from the Neves Corvo mine in Portugal, which will commence operations in 1988.

Les Mines Selbaie announced a $9.5 million program to develop its underground A2 zone. The 1.9 Mt orebody grades 2.24% Cu, 1.04% Zn, 1.23 g/t Au and 19.4 g/t Ag to a depth of 240 m. By the end of 1988, the A2 and B zones will be mined simultaneously at a rate of 1650 t/d. This will extend the life of the B zone and minimize capital costs to develop the A2 zone as the B zone crusher and shaft will be used for A2 ore. The A1 pit will continue operations at a rate of 5000 t/d. Total production in 1988 is forecast at 23 500 t of copper in concentrates.

Corporation Falconbridge Copper was renamed Minnova Inc. The company sold $65 million of debentures to raise money for completion of development at its Winston Lake and Ansil projects. Shaft sinking at Ansil was halted to allow detailed diamond drilling of the main orebody. A ventilation raise was sunk while drilling was completed. At year end, calculation of detailed ore reserves was under way. The operation is expected to start production in 1989 at a rate of about 500 000 t/y of ore.

Audrey Resources Inc. officially opened the Mobrun pit in July. As well, underground operations began in mid-October via a 230 m shaft. Over 1.5 Mt of copper-zinc-gold-silver ore have been delineated, sufficient for five years of operations. The ore is presently being milled at Minnova Inc.'s Norbec mill, but start up of Ansil would force Audrey to seek other arrangements or to construct its own mill.

The strike that began November 5, 1986 at Noranda's Horne smelter was settled effective February 22. The smelter resumed normal operations in March. This strike restricted feed to Noranda's refinery, reducing total Canadian refined production in 1987 from what had been forecasted earlier. The smelter was again briefly closed in October for some rebricking and in mid-December,

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the company announced that refined shipments in the first two months of 1988 would be reduced. An agreement was announced in April whereby an acid plant will be built at the Horne smelter to reduce sulphur dioxide emissions. The agreement was the result of extensive negotiations between the company and the federal and provincial governments. The acid plant will be operational by the end of 1989.

Campbell Resources Inc. declared commercial production in its S-3 gold-copper property on January 2. On April 2, Meston Lake Resources Inc. declared commercial production at its Joe Mann gold-copper mine, in which Campbell had a 65% control of voting rights. Later in the year, Campbell acquired the minority holdings of Meston Lake Resources. Campbell's other two properties in the Chibougamau camp are the Henderson II and Cedar Bay gold-copper mines. Western Mining Corporation Holdings Limited agreed to purchase Northgate Exploration Limited's gold-copper operations in Chibougamau.

The **Ontario** mining operations of INCO Limited and Falconbridge Limited in the Sudbury basin are reviewed in the nickel chapter of the Yearbook. INCO plans a five week vacation shutdown of its Ontario operations in 1988 despite tightness in both copper and nickel markets in late 1987. The expansion of Falconbridge's copper smelting and refining operations to 92 000 t/y at its Kidd Creek operations was completed in 1987. The smelter was shut down for five weeks at the end of September for maintenance and modifications related to the expansion, after having run continuously for over 15 months.

Metallgesellschaft AG (MG) formed Metall Mining Corporation in Canada to consolidate MG's international mining interests. Holdings of Metall, owned 63% by MG, include 11.1% of Teck Corporation, 7.3% of Cominco Ltd., 16.7% the joint venture operating the Afton mine, 7.5% of Ok Tedi Mining Limited, 4% of M.I.M. Holdings Limited, and 24.5% of the Cayeli Bakir Isletmeleri A.S. zinc-copper deposit in Turkey.

In **Manitoba,** the Ruttan mine was sold by Sherritt Gordon Mines Limited to Hudson Bay Mining and Smelting Co., Limited (HBM&S) effective July 30. Sherritt had previously announced its intention to close Ruttan. The sale improves the reserve base of HBM&S, which also operates a copper smelter in the province.

At the Trout mine, work started on a $17 million shaft. The 640 m shaft will replace truck haulage and permit mining at greater depths.

British Columbia produced an estimated 48% of Canada's recoverable copper mine production in 1987. It is the world's largest exporter of copper in concentrates, accounting for about 23% of western world exports of 1.45 Mt.

The largest Canadian copper producer is Highland Valley Copper (HVC), a partnership of Cominco Ltd. and Lornex Mining Corporation Ltd. HVC completed installation of twin semi-mobile in-pit crushers and conveyors by December at a cost of $17 million. The Lornex and Bethlehem mills operated at 120 000 t/d by year-end, supplied with ore primarily from the Valley pit. Teck Corporation and the HVC partners continued negotiations to merge Highmont Mining Corporation's facilities into the HVC operations. Highmont is a partnership owned 50% by Teck, 20% by Metall Mining and 30% by a subsidiary of Kuwait Investment Office of London.

Newmont Mining Corporation wrote down the value of its Canadian subsidiary Newmont Mines Limited by US$38 million in early 1987. At that time the company did not foresee copper prices which would permit recovery of its investment: Newmont Mines Limited reported a loss for each year from 1981 to 1986. Westmin Resources Limited began a program to expand its 3000 t/d mill to 4000 t/d. The $26 million project is scheduled for completion in late 1988. Gibralter Mines Limited successfully ran its 4500 t/y leach-solvent extraction electrowinning (SXEW) operation through the winter. Unlike conditions at most SXEW plants, the winter temperatures at Gibralter are below freezing for extended periods of time.

Afton Operating Corporation ceased mining its main pit in mid-year, switching to the 2.3 Mt, 0.39% Cu Pothook pit as well as processing stockpiled ore. During the summer, the company conducted an exploration program on a property about 10 km from its mill. Afton is considering a $10 million project to develop the property to provide ore once the Pothook pit is mined out (in 1988). Afton also has 10 Mt of underground reserves grading 1.5% Cu and 0.9 g/t Au but development of these reserves is considered uneconomic unless high copper prices are sustained.

Geddes Resources Limited raised $6 million for further exploration of the Windy Craggy gold-copper deposit. Over 1800 m of underground development and over 3000 m of diamond drilling will be completed to further delineate the deposit. An apparent strike length of over 2000 m of sulphide mineralization containing copper, cobalt, gold and silver has been demonstrated. Drilling of the underground gold zone, the copper zone, bulk sampling and assessment of the results are scheduled for completion in 1988. Earlier preliminary estimates for the copper zone put reserves at 110 Mt of 2.4% Cu material within 350 Mt of 1.5% Cu.

In Canada, exploration for copper deposits has been discouraged by low prices. Few existing producers replaced ore reserves at their rate of depletion, nor were sufficient new deposits discovered to maintain the reserve base. Consequently Canadian production is expected to decline as producers exhaust their orebodies. Higher prices in late 1987 prompted some producers to re-examine existing mining plans to increase mineable reserves. However, prices would have to be maintained above US75¢/lb. to offset the projected decline in national copper output.

WORLD EVENTS

Copper producers in the western world continued to operate as efficiently as possible. The low prices for most of 1987 continued to keep many operations at levels of marginal profitability. The backwardation for three month copper that began March 4, when spot prices were US65¢/lb. continued until year-end. The backwardation increased to 8¢ in late October, reached 27¢ in mid-November and ended the year varying around the 20¢ (see Figure 3). The continued backwardation indicated that most market participants expected prices would decline, perhaps as demand weakened for the summer vacation period. However, demand proved stronger and more sustained than expected, especially in the United States and Asia.

Seriously weakened by prolonged low prices, producers operated only their most efficient facilities, generally at full capacity. Meanwhile consumers had gotten used to maintaining minimum inventories. Thus the copper supply "pipeline" was shortened, removing the industry's flexibility to expand production on short notice to meet surges in demand. Consequently, when demand did not slacken during the summer as had been expected, consumers bid up spot prices to obtain metal to keep plants running. Custom smelters, principally Japanese, also faced with increased demand, chose to bid for spot metal rather than bid down treatment and refining charges (TCRCs). Spot metal prices are immediate costs that can be passed along directly to customers, whereas extra demand for concentrates reduces the smelters' bargaining position with both existing and future suppliers.

Non-socialist world mine production in 1987 is estimated at about 6.7 Mt while refined consumption is estimated at about 7.7 Mt or roughly the same as 1986.

In the **United States,** producers continued programs to reduce costs, including the installation of lower cost leach-solvent extraction and electrowinning (SXEW) facilities. U.S. production in 1987 is estimated at 1.27 Mt of recoverable mine copper and 1.56 Mt of refined copper, of which 0.43 Mt was secondary material. Apparent consumption is estimated at 2.19 Mt.

In March, Newmont Mining Corporation spun off Magma Copper Company, distributing 80% of the equity to its shareholders, retaining 15%, and holding 5% for future profit-sharing distribution to Magma employees. Magma's new US$130 million, 270 000 t/y smelter will be the world's largest flash smelter when completed. Mechanized mining trials in the underground mine proved unsuccessful due to higher costs and lower recoveries. Future mining at Magma and the new Kalamazoo orebody will be done by traditional, more labour intensive methods. Magma will achieve future cost reductions at the mine by raising the cutoff grade from 0.4% to 0.5% Cu.

Phelps Dodge Corporation (PD) ceased operations at its 120 000 t/y Douglas smelter in mid-January in accordance with an environmental agreement negotiated in 1986. At PD's Morenci operation, commissioning of a 45 000 t/y SXEW operations started in October. The plant is expected to be running at full capacity by the end of January 1988. Expansion of the SXEW facilities by 50% will start once the original plant is operational. PD began a US$40 million in-pit crushing and conveying project at the Morenci mine, scheduled for completion in 1989. At PD's Tyrone mine, SXEW facilities will be expanded by 20% to 38 000 t/y. By the end of 1988 PD will build a 40 000 t/y SXEW plant at its Chino operation at a cost of US$55 million. PD forecast that by the early 1990s its electrowon copper production would be 135 000 t/y, out of an expected total production of 400 000 t/y. PD expects to lower its mining costs to less than US50¢/lb. by mid-1989, largely by increasing production of lower cost (about 30¢/lb.) SXEW production.

ASARCO Incorporated purchased Anamax Mining Company's share of the Eisenhower Mining Company. The purchase completed ASARCO's ownership of the Mission complex in Arizona. In December, ASARCO announced that copper output from the Mission complex would increase by 24 000 t/y to 78 000 t/y within the year.

Inspiration Consolidated Copper Company will expand its 45 300 t/y SXEW facilities by 25% to 56 700 t/y, at a cost of US$15 million. Inspiration continues to operate its electric smelter, tolling copper concentrates and copper precipitates.

Mitsubishi Metal Corporation studied development of a 100 000 to 150 000 t/y U.S. copper smelter, either on the Gulf or Atlantic coast. Mitsubishi Corporation has a share in the Escondida property in Chile, and would have preferred access to concentrates from the project. Mitsubishi Metal America Corp. took a 20% equity position in the Cox Creek Refining Company operation near Baltimore. Cox Creek's 180 000 t/y rod plant started operation in August while the 180 000 t/y refinery was commencing operations in late December. The refinery can be expanded relatively inexpensively to 270 000 t/y.

Cyprus Mineral Company purchased Noranda's Lakeshore mine in Arizona. The property, renamed Cyprus Casa Grande, has a 135 000 t/y roasting plant, an acid plant and 40 000 t/y electrowinning facilities. Noranda had converted the underground mine into an in-situ leach operation which yielded about 4500 t/y of electrowon copper. The acquisition will give Cyprus the capacity to treat its Sierrita concentrates once the smelting contract with Inspiration finishes: the sulphide concentrates would be roasted to oxide, then put through the electrowinning plant.

In **Chile**, copper production for the first eight months declined slightly by 13 000 t to 907 000 t, with Corporacion Nacional del Cobre de Chile (CODELCO-CHILE) production dropping by 25 000 t to 709 000 t for the period. Exports for the first nine months totalled 990 000 t, compared with 953 000 t for the same period a year earlier.

CODELCO announced that the Andina division would increase its capacity from 33 000 t/d to 40 000 t/d by 1988. This would boost production at the mine from 115 000 t/y of copper in concentrates to 140 000 t/y. The expansion of CODELCO's Chuquicamata facilities continued on schedule. The mine concentrator, and refinery will be expanded. A new smelter and acid plant are under construction.

Empresa Nacional de Mineria (ENAMI) called for pre-qualification bids for an oxygen plant at its Ventanas smelter to increase the smelter's capacity by about 55 000 t/y of copper. Construction of the oxygen plant and an acid plant are to be completed by 1991, for a cost of US$72 million. Cia. Minera Disputada de las Condes SA completed a two year, US$60 million expansion of the El Soldado mine and concentrator capacity from 5 500 t/d to 13 000 t/d.

Sulphuric acid from the new acid plant under construction at Chuquicamata will be sold to local miners for US$25/t; the present price is about $75/t. Once acid plants at CODELCO and ENAMI are completed, the supply of acid in Chile will increase significantly. The government hopes lower acid prices will allow small and medium sized miners to increase copper production from copper oxide reserves.

The Escondida project owners are expected to make a production decision by mid-June 1988. The project is owned 60% by The Broken Hill Proprietary Company Limited (BHP), 30% by The RTZ Corporation PLC, and 10% by Mitsubishi. BHP also owns 30% of the Ok Tedi operation while RTZ also owns 49% of the Neves Corvo project in Portugal. Delays in the decision-making process may be the result of complicated financing negotiations, the lack of a smelting/refining contract with smelters (some of whom are expected to guarantee loans to develop Escondida) and possible disagreement between the banks and the owners about the degree to which lending would be on a project-financing basis. The

International Finance Corporation is considering taking a minor equity position in the project, but no decision was reached by year-end. Escondida will produce about 325 000 t/y of copper in concentrates for an investment of over US$1000 million.

In **Peru,** Empresa Minera Especial Tintaya S.A. studied a proposal to build a smelter to process 175 000 t/y of concentrates grading 33% Cu. At the Cerro Verde mine, problems were reported with bacterial leaching. A US$35 million modification to remove fines prior to leaching was proposed. The change would reduce electrowon cathode production but increase output of copper in concentrates.

In **Brazil,** Caraiba Metais S.A. began expansion of its copper smelter and refinery from 150 000 t/y to 200 000 t/y. The smelter and refinery will likely be sold to the association of copper consumers in Brazil for US$500 million, payable over 4 years.

In May, it was estimated that copper demand in Brazil would reach 300 000 t for 1987, up from 206 000 t for 1986. Companhia Vale do Rio Doce (CVRD) contracted out conceptual and feasibility studies of its Salobo deposit in the Carajas region. Test work completed in 1986 yielded 3800 t of concentrates. Production levels of 300 000 t/y of copper concentrates grading 41% Cu have been suggested but due to CVRD's debt load, a smaller, lower-cost plant is being considered.

Cia. Paraibuna de Metais SA (CPM) proposed building a 100 000 t/y smelter and refinery at Sao Luis, Carajas. Construction of the US$150 million facility could start in mid-1988 with startup likely in early 1990 and full capacity to be reached in 1991. CPM contacted overseas producers to discuss possible concentrate supply arrangements, as any concentrates from the Salobo deposit will likely be first sent to the existing Caraiba Metais smelter. At year end, CPM was reportedly considering construction of just a 100 000 t/y refinery, based on imported blister.

Japan's estimated copper production in 1987 is 0.955 Mt compared with a domestic demand estimated at 1.42 Mt. Due to higher than forecast demand (earlier estimates had put demand at 1.33 Mt in 1987), Japanese imports of cathode for 1987 were expected to rise to 350 000 t from the previous estimate of 290 000 t. In the first half of 1987, total refined imports were 150 000 t while concentrate imports declined by 5% compared to the same period in 1986. Japanese smelting and refining companies preferred to import cathode rather than additional concentrates to meet the increased demand. The continued backwardation made smelters reticent to purchase spot concentrates.

Japanese smelters and refiners have faced financial pressure due to the increased value of the yen: their revenues (TCRCs) are denominated in U.S. currency whereas their operating costs are primarily in yen. Hence, their costs rose faster than revenues, much like the conditions that faced American and Canadian producers earlier in the decade.

In October, Japanese smelters began negotiations for 1988 with the three mines, that have agreed to partially yen-based contracts for treatment and refining charges (TCRCs), Butte, Cananea and Ok Tedi. In November, Japanese smelters and refiners were reported to be asking for TCRCs of US$70/t and US9¢/lb. for long term contracts commencing in 1988. However spot material was being offered TCRCs of $50/t and 7¢/lb. in September and $45/t and US6.25¢/lb. in October, depending upon the quotational period.

Discussions continued between Noranda and Chinese officials on a possible 100 000 t/y smelter and refinery at Tianjin: no decision was reached by the end of 1987. Chinese copper production was estimated at 300 000 t/y with consumption put at 500 000 t/y in a paper at the Copper 87 conference held in Chile in December. Consumption was forecast to rise to about 850 000 t/y by the end of the century.

Malaysia's copper producer, Mamut Mines Development Co. Ltd. was kept open following a refinancing agreement with Japanese lenders. Mitsubishi will take the entire output of 29 000 t/y of copper in concentrates.

In **India,** the government authorized an increase in 1987 copper imports to 80 000 t from 50 000 t in 1986, while the import tax on copper was raised from 115% to 135% ad valorem. The Japanese Overseas Economic Cooperation Fund pledged 2 700 million yen (US$19 million at an exchange rate of 140 yen/US$) in loans to Hindustan Copper Ltd. to pay for engineering studies for the expansion of the Malanjkhand mine. About

100 000 t/y of additional copper might be produced by an expansion. Such an expansion is not foreseen until the mid-1990s.

In **Pakistan,** the government authorized Resources Development Corp. to obtain sovereign-risk loans for the development of the Saindak copper project. Roumania offered to provide US$120 million towards the project, while China offered assistance in return for participation in a joint venture. The US$250 million project would produce 18 500 t/y of blister copper, as well as gold and silver. The breakeven price of the project was put at US66¢/lb. for copper and US$345/oz. for gold.

A typhoon damaged the 50 000 t/y Keeling smelter and refinery in **Taiwan** in late October. Force majeure was declared for two months: the facilities resumed full production at the start of 1988.

Australian copper production is estimated at 250 000 t in 1987 and forecast at 280 000 t in 1988. The government of Tasmania offered financial assistance to the Mt. Lyell operation to extend operations to 1994. The new aid package, the third for Mt. Lyell since 1977, included a cash advance at the long-term bond rate, power concessions and deferred royalties and payroll taxes. The operation previously had been scheduled to close in 1989. Production will be maintained at 24 000 t/y of copper in concentrates.

The Olympic Dam uranium-copper-gold property will begin production in mid-1988. Copper output will initially be 30 000 t/y of refined copper. The copper smelter and refinery will have capacities of 55 000 t/y to allow for future expansion of mine output. At the Mount Isa operations of M.I.M. Holdings Limited, construction of the ISASMELT process was completed, boosting smelting capacity of the operation by 30 000 t/y of metal. ASARCO reduced its holdings in M.I.M. from 35% to 19% while M.I.M.'s holdings of ASARCO remained at 24%. M.I.M. obtained a 35% interest in the Norddeutsche Affinerie AG copper smelter and refinery in Hamburg, Federal Republic of Germany, including 5% from MG in exchange for 3% of M.I.M.'s outstanding shares.

In the **Philippines,** copper production in the first seven months of the year declined 3% to 124 500 t compared to the same period in 1986 but is expected to total 220 000 t, in the year as a whole, slightly above the 1986 level of 217 000 t. The state-owned smelter and refinery, Philippine Associated Smelting and Refining Corp. (PASAR), contracted to import about 120 000 t of concentrates in 1988. The Japan Overseas Economic Cooperation Fund will finance a 25% increase in PASAR's capacity to 172 500 t/y, at a cost of US$50 million.

In **Papua New Guinea,** management of Ok Tedi Mining Limited (OTML) was assumed by BHP, effective October. As of April, the forecast for copper in concentrates production was: 1987, 63 000 t; 1988, 158 000 t; 1989, 207 000 t; 1990, 195 000 t; 1991, 144 000 t. Copper production started in June and the first concentrates were shipped in early July, but since then production has been less than scheduled. OTML signed a five year agreement with Japanese smelters with TCRCs reported by US$68/t and US8¢/lb., about one-third of the material quoted in yen terms. During the year, a study of a copper smelter for Ok Tedi and other concentrates was started but later abandoned. Bougainville Copper Limited negotiated a contract with Japanese smelters reportedly with TCRCs of US$60/t and US8¢/lb.

In **Zaïre,** Générale des Carrières et des Mines du Zaïre (Gécamines) absorbed Société de Développement industriel & minière du Zaïre (SODIMIZA) effective April 30. Gécamines continued investments to rehabilitate and improve its operations: two in-pit mobile primary crushers with conveyors and a stacker for waste will be installed by 1990, financed by the World Bank. The Banque Européenne d'Investissement is financing a US$50 million rehabilitation of the Kolwezi concentrator, due for completion in mid-1989. The Banque Africane de Développement will finance a 100 000 t/y electrolytic refinery planned to be in operation by 1990.

In **Zambia,** Zambia Consolidated Copper Mines Limited (ZCCM) undertook a major rationalization of its operations. It closed the Konkola No. 3 shaft, the Chambeshi mine and concentrator, the Kansanshi open pit, the Lyanshya smelter, the Ndola refinery and Nkana oxide concentrator. In May, Zambia decided to restrict debt repayments which effectively cut off Zambia from further IMF loans. Subsequently the government announced a US$42 million investment plan for the copper sector. ZCCM projects production to rise from the 470 000 t in fiscal (April to March) 1987-88 to 497 000 t in fiscal 1988-89. Higher copper prices allowed ZCCM to restock spares and supplies as shortages have restricted output. ZCCM copper production was 125 000 t in the third quarter, up 11 000 t from the same period in 1986.

In **South Africa,** the Palabora operation will install an in-pit crusher and conveyor by the end of 1988. A CON-TOP smelting cyclone will also be installed to increase capacity of the existing reverberatory furnace to match that of the 140 000 t/y refinery.

In **Portugal,** the US$400 million development of the Neves Corvo deposit continued, assisted by a European Investment Bank loan of US$210 million. The concentrator should be finished by late 1988 and should operate at capacity in 1990. The mine should generate about 450 000 t/y of concentrates (grading 25% Cu) by mining 1.3 Mt/y of ore grading 8% Cu. The Portuguese government continued a feasibility study for a 100 000 t/y copper smelter and refinery at Sines. The Neves Corvo operation would be obliged to provide feed if the US$300 million complex were to be built.

In **Spain,** Rio Tinto Minera SA notified its bankers in early 1987 that it could not make further payments on its debts, estimated at US$150 million, and the mines were placed on standby. The company's 115 000 t/y smelter and refinery at Huelva remained in operation, processing imported concentrates.

In **Sweden,** Boliden AB announced that it would reduce pollution at its Ronnskar copper and lead smelter. By 1989, Boliden will close the older copper circuit, and upgrade the acid plants. Smelter capacity will be 95 000 t/y of blister, matching that of the refinery, but employment at Ronnskar will be reduced by 400 jobs. Boliden planned to spend about US$450 million on domestic mine developments to maintain feed for the Ronnskar smelter. The company had asked the government to provide at least 35% of the financing, but in mid-December the government offered only about 3% of the financing. As a result, the company stated it would probably have to cut back domestic operations, threatening the viability of its mining activities in central Sweden.

INTERNATIONAL EVENTS

Two meetings were hosted by the United Nations Committee on Trade and Development (UNCTAD) in Geneva to discuss the U.S.-proposed international producer-consumer forum for copper. The United States envisages the group as a classical study group, akin to the International Lead and Zinc Study Group (ILZSG). Participants agreed to schedule a negotiating meeting in the first half of 1988. Major unresolved issues include whether the group should be autonomous or established within UNCTAD, whether the group would have market promotion functions and the degree to which improved statistical efforts would avoid duplicating the efforts of existing organizations. No market intervention functions are being considered for the group.

"Copper 87", an international copper conference, was jointly sponsored by Chilean and Canadian mining and metallurgical societies and the University of Chile. It dealt with outlook for copper, mineral dressing, metallurgy and new copper based materials.

METALS EXCHANGES AND PRICES

Combined LME and COMEX stocks declined from a level of 260 879 t on January 2, 1987 to 69 712 t on January 1, 1988 (see Figure 2). The LME established Singapore as a delivery point for copper effective January 1, 1988 while COMEX opened a new warehouse in Salt Lake City.

Copper prices averaged US80.1¢/lb. for Grade A copper on the LME and US77.8¢/lb. for 1st position COMEX copper. As can be seen from the graph of copper prices for 1986 and 1987 (Figure 1) and the table of monthly LME prices, the greatest changes occured in the fourth quarter. The decline in the value of the U.S. dollar also contributed to the dollar-denominated price increase. The backwardation for three month copper is shown in Figure 3. The backwardation for 15 month Grade A copper reached US47.8¢/lb. at year end.

USES

Copper is the preferred material when superior electrical or thermal conductivity and corrosion resistance are desired.

Copper's electrical conductivity is over 60% greater than that of aluminum and its thermal conductivity is over 75% higher. Hence copper's main uses are in the transmission of electrical energy and electrical signals, water transmission and for heat transfer.

Copper potentially has additional benefits when used in water distribution systems. Research is ongoing about copper's potential to reduce bacterial levels in water supply systems. Preliminary research from a survey of 104 hotels found that 44 had water systems testing positive for the presence of **Legionella** bacteria, which are associated with Legionnaire's disease and Pontiac fever. In the eight hotels with water systems made entirely of copper, no Legionella were found. Other research has shown that **Legionella pneumophila** were rarely found on copper surfaces. The International Copper Research Association (INCRA) has funded part of the research.

OUTLOOK

Consumption of refined copper is expected to be 7.8 Mt in 1988, up slightly from 1987. Future consumption should continue to increase, trending to about 8.5 Mt in 1995. This growth is based on the assumption that debt problems in developing countries will ease and that world economic growth will continue, thus permitting increased development of infrastructure which increases copper demand.

The higher prices of the latter part of 1987 are not likely to be sustainable through 1988. Even before the higher prices of late 1987, substantial additional production capacity was under construction, such as Ok Tedi, Olympic Dam, Neves Corvo, CODELCO expansions, the Highland Valley Copper expansion, and SXEW facilities and planned reopenings in the U.S.

Unless demand accelerates beyond forecasted levels, a surplus will be created by the latter half of 1988 and increase through 1989. Prices are therefore expected to fall as copper becomes increasingly available. If the U.S. dollar were to decline further, dollar-denominated copper prices would be supported. High inflation rates would also tend to push up the price of most commodities. But the large backwardation in prices indicates that the copper market expected future prices will decline.

The longer high prices continue, the more likely that other potential projects, previously judged uneconomic, will be given financing to proceed. Development of many new projects based on the premise that prices of late 1987 would be representative of future copper prices, would ensure that prices will fall. In the longer term increased demand could offset capacity expansion, but insufficient funding is being provided to market promotion organizations such as the Copper Development Associations (CDAs) and The International Copper Research Association Inc.

As copper supply and demand became more closely balanced after several years of excess supply, only a relatively small shift in the supply/demand balance was required to cause major shifts in the prices. The reverse could easily occur if supply increases or demand declines.

From the perspective of early January 1988, copper prices in 1988 are expected to be higher in the first half of the year than in the second half, and to average about US85¢/lb. for the year, with prices at the end of 1988 in the range of 70 to 75¢ although further significant changes in the value of the U.S. dollar could result in partly compensating changes in the copper price.

In the longer term, copper prices are expected to continue the trend that has been evident since 1965: current monthly average prices have averaged 0.6 Special Drawing Rights/lb. (SDR/lb.) varying for the most part within a range of 0.45 to 0.75 SDR/lb. (see Figure 4). Assuming a long term value of U.S. currency of US$1.40 = SDR 1.0 (year end 1987 value), the longer term average price would be US$0.84/lb. varying for the most part within a range of US$0.63 to 1.05/lb.

For the period 1965 to 1987, changes in copper prices denominated in SDRs/lb. have not correlated with changes in inflation. In the future, if economic growth and inflationary conditions resemble those of the period 1965 to 1987, then copper prices in SDRs/lb. can be expected to fluctuate about an average that does not rise with time. Increased productivity, brought about largely through the application of more advanced technologies should continue to allow the industry to offset inflation of input costs.

TABLE 1. CANADA, COPPER PRODUCTION, TRADE AND CONSUMPTION, 1985-87

	1985		1986P		1987e	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Shipments[1]						
British Columbia	299 560	594 926	306 855	626 598	348 246	837 183
Ontario	284 692	565 398	264 870	540 865	280 634	697 643
Manitoba	69 071	146 032	65 369	133 483	71 791	172 586
Quebec	73 531	137 175	51 622	105 412	56 378	135 532
New Brunswick	6 774	13 454	6 298	12 860	7 767	18 673
Saskatchewan	4 976	9 882	3 506	7 160	2 474	5 948
Yukon	10	19	6	13	9	22
Northwest Territories	23	46	1	1	0	0
Total	738 637	1 466 932	698 527	1 426 392	767 299	1 667 587
Refinery output	499 626	..	493 445	..	495 000	..
Exports						
Copper in ores, concentrate and matte					(Jan.-Sept. 1987)	
Japan	237 869	340 177	253 686	365 723	175 215	255 406
People's Republic of China	16 026	26 488	30 373	42 911	25 861	36 082
Taiwan	29 582	40 690	14 793	22 092	19 932	26 489
Norway	28 076	4 528	20 223	33 164	11 462	16 930
Finland	0	0	0	0	8 037	10 770
South Korea	4 415	6 481	14 007	20 248	7 855	9 314
Spain	0	0	3 703	4 057	6 113	8 382
West Germany	0	0	0	0	3 528	4 870
Belgium-Luxembourg	1 005	610	1 085	542	3 524	3 758
United Kingdom	897	1 639	870	1 564	634	1 233
United States	394	74	2 650	3 851	222	33
Brazil	2 355	3 266	0	0	0	0
Total	320 619	423 953	341 390	494 152	262 379	373 267
Copper in slag, skimmings and sludge						
Italy	322	152	250	99	0	0
United States	3 449	950	1	7	0	0
Total	3 771	1 102	251	106	0	0
Copper scrap (gross weight)						
United States	26 094	3 914	29 530	50 069	26 062	43 706
West Germany	2 980	4 740	8 625	10 135	915	1 312
South Korea	835	1 178	1 213	1 735	478	689
United Kingdom	3 759	5 378	384	635	164	194
Netherlands	1 004	1 722	970	1 598	58	84
Other countries	4 865	6 623	1 965	2 569	2 793	3 587
Total	39 537	58 789	43 818	68 602	30 470	49 572
Brass and bronze scrap (gross weight)						
United States	9 215	11 227	12 285	15 462	9 902	12 802
West Germany	1 908	2 364	822	1 115	1 276	1 575
Brazil	40	46	786	1 392	562	833
United Kingdom	199	342	401	392	576	761
India	537	454	932	787	900	687
Taiwan	475	573	901	1 067	444	518
Japan	155	120	246	288	349	513
South Korea	92	106	319	399	393	462
Belgium-Luxembourg	1 149	1 501	441	525	273	337
Netherlands	429	553	359	540	183	215
Italy	1 849	2 261	1 831	2 239	152	156
Other countries	199	291	122	155	303	235
Total	16 247	19 838	19 445	24 361	15 313	19 094
Copper alloy scrap, n.e.s. (gross weight)						
United States	4 311	4 224	5 637	5 672	4 774	5 197
Other countries	2 378	2 950	1 107	1 122	1 425	1 576
Total	6 689	7 174	6 744	6 794	6 199	6 773
Copper refinery shapes						
United States	135 488	258 792	193 597	380 517	151 655	313 728
United Kingdom	42 044	80 856	53 984	104 047	28 799	55 129
Italy	4 306	8 151	8 786	17 393	7 077	14 707
Netherlands	25 060	42 733	8 030	14 986	7 493	12 843
Sweden	9 699	18 550	9 708	18 869	6 420	11 881
West Germany	18 151	32 244	15 038	29 477	5 348	9 769
People's Republic of China	24 063	40 921	3 300	6 379	3 995	8 981
Belgium-Luxembourg	8 846	17 155	6 246	11 145	3 618	8 965
France	10 431	19 653	4 315	8 360	3 662	7 188
Portugal	560	1 032	1 800	3 317	758	1 620
Other countries	1 385	2 839	18	52	797	1 806
Total	280 033	524 926	304 822	594 544	219 622	446 617

TABLE 1. (cont'd.)

	1985		1986P		(Jan.-Sept.) 1987	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Copper bars, rods and shapes, n.e.s.						
United States	11 549	27 780	12 057	29 302	8 614	21 596
India	49	88	361	696	1 954	3 693
Venezuela	1 303	2 765	1 486	3 363	1 462	3 182
Bangladesh	1 544	3 137	2 477	5 207	766	1 521
Other countries	5 025	10 160	2 236	4 991	1 488	2 950
Total	19 470	43 930	18 617	43 559	14 284	32 942
Copper plates, sheet and flat products						
United States	4 802	16 173	3 750	12 607	3 318	11 353
India	3 503	6 424	10	78	0	0
Other countries	1	9	264	804	318	1 036
Total	8 306	22 605	4 024	13 411	3 636	12 389
Copper pipe and tubing						
United States	4 816	14 391	5 715	17 590	3 886	13 081
Israel	707	1 954	524	1 549	485	1 445
Other countries	154	466	360	1 620	402	1 611
Total	5 677	16 811	6 599	20 759	4 773	16 137
Copper wire and cable (not insulated)						
United States	196	623	466	300	420	1 164
Mexico	18	43	163	355	154	415
Saudi Arabia	38	122	0	0	0	0
Japan	41	63	37	68	0	0
India	0	0	68	145	0	0
Other countries	71	364	99	344	56	164
Total	364	1 215	833	2 208	640	1 743
Copper alloy shapes and sections						
United States	12 928	36 822	16 890	40 609	16 669	41 783
Other countries	98	275	16	109	256	624
Total	13 026	37 097	16 906	40 718	16 925	42 407
Copper alloy pipe and tubing						
United States	3 612	12 884	1 686	7 866	1 175	4 841
Other countries	79	243	30	155	86	399
Total	3 691	13 127	1 716	8 021	1 261	5 240
Copper alloy wire and cable, not insulated						
United States	327	898	109	467	183	462
Other countries	13	91	31	136	15	162
Total	340	989	140	603	198	624
Copper and alloy fabricated materials, n.e.s.						
United States	1 306	4 943	971	4 662	1 059	4 056
Other countries	334	798	307	1 212	102	775
Total	1 640	5 741	1 278	5 874	1 161	4 831
Total copper exports	..	1 218 053	..	1 323 711	..	1 011 638
Copper Imports						
Copper scrap	77 749	90 928	59 291	78 789	47 226	62 581
Copper in ores and concentrates	76 137	66 139	70 700	73 377	40 176	51 303
Copper alloy scrap	7 454	8 780	6 476	8 163	3 695	5 433
Copper oxides and hydroxides	270	759	463	1 179	420	1 144
Copper sulphate	1 381	1 102	3 849	3 050	3 408	2 539
Copper, refinery shapes	19 131	39 409	20 901	42 579	13 909	27 925
Copper bars, rods and shapes, n.e.s.	5 656	12 583	7 113	16 224	10 421	23 261
Copper plates, sheet and flat	4 820	13 494	2 921	8 725	1 906	5 571
Copper pipe and tubing	3 424	12 029	2 734	9 852	2 330	8 072
Copper wire and cable, not insulated	3 949	15 327	3 821	15 183	4 065	14 267
Copper powder	747	1 919	976	2 392	623	1 656
Copper alloy refinery shapes	11 428	28 559	13 290	33 548	12 496	30 357
Brass plates, sheet, strip, etc.	4 002	12 836	5 763	18 440	3 934	12 002
Copper alloy plates, sheet, etc.	1 638	7 705	1 569	8 701	953	5 533
Copper alloy pipe and tubing	3 775	18 000	4 776	23 356	3 805	18 356
Copper alloy wire and cable, not insul.	1 506	5 021	1 506	5 019	1 473	4 755
Copper alloy castings	551	3 628	741	4 051	548	3 472
Copper and copper alloy fab. materials	2 731	13 813	3 182	16 226	3 084	14 696
Valves, brass, n.e.s.	..	25 765	..	25 072	..	21 827
Pipe fittings, copper and copper alloy	..	18 129	..	19 532	..	20 040
Total copper imports[2]	..	395 925	..	414 265	..	334 788

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Blister copper recovered from domestic concentrates plus recoverable copper in matte and concentrate exported; totals may not add due to independent rounding. [2] Total imported tonnage does not include insulated wire and cable, valves or pipe fittings.

.. Not available or not applicable; n.e.s. Not elsewhere specified; P Preliminary; e Estimated.

TABLE 2. CANADA, COPPER PRODUCTION, TRADE AND CONSUMPTION, 1970, 1975, 1980 AND 1984-87

	Production		Exports			Imports	Consumption[2]
	Shipments[1]	Refinery Output	Concentrates and Matte +	Refined =	Total	Refined	Refined
				(tonnes)			
1970	610 279	493 261	161 377	265 264	426 641	13 192	229 026
1975	733 826	529 197	314 518	320 705	635 223	10 908	196 106
1980	716 363	505 238	286 076	335 022	621 098	13 466	208 590
1984	721 826	504 262	332 373	345 985	685 032	25 563	231 039
1985r	738 637	499 626	320 619	280 033	600 652	19 131	222 466
1986P	698 527	493 445	371 390	304 822	676 212	20 901	204 685
1987e	767 000	495 000	262 379[3]	219 622[3]	482 001[3]	13 909[3]	175 000[3]

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Blister copper plus recoverable copper in matte and concentrate exported. [2] Producers' domestic shipments of refined copper plus imports of refined shapes. [3] January to September 1987 data.
P Preliminary; e Estimated; r Revised.

TABLE 3. WESTERN WORLD MINE PRODUCTION OF RECOVERABLE COPPER IN CONCENTRATES, 1986-88

	1986	1987P	1988f
		(000 tonnes)	
Chile	1 400	1 415	1 490
United States	1 150	1 200	1 300
Canada	699[1]	767[1]	745
Zambia	470	510	530
Zaire	505	505	510
Peru	397	405	421
Australia	260	250	280
Papua New Guinea	178	200	270
Philippines	217	220	230
Other	1 224	1 128	1 124
Total	6 500	6 700	6 900

Sources: World Bureau of Metal Statistics; U.S. Bureau of Mines; Energy, Mines and Resources Canada.
[1] Shipments.
f Forecast; P Preliminary.

TABLE 4. WESTERN WORLD PRODUCTION OF REFINED COPPER[1],[2] 1986 AND 1987

	1986	1987P
	(000 t)	
United States	1 480	1 500
Japan	945	975
Chile	945	1 000
Canada	493	545
Zambia[3]	488	500
Germany, Federal Republic	422	425
Zaire	218	220
Other	2 459	2 435
Total	7 450	7 600

Sources: World Bureau of Metal Statistics; U.S. Bureau of Mines; Energy, Mines and Resources Canada; private communications.
Data as available January 11, 1988.
[1] Includes primary, secondary and electrowon copper. [2] Includes Yugoslavia. [3] Includes some material from Zaire.
P Preliminary.

TABLE 5. CANADIAN COPPER AND COPPER-NICKEL SMELTERS

Company and Location	Product	Rated Annual Capacity	Blister or Anode Copper Produced in 1986[1]	Remarks
		(tonnes of concentrates)	(tonnes)	
Falconbridge Limited Falconbridge, Ont.	Copper nickel matte	570 000	21 100	Fluid bed roasters and electric furnaces; 1 800 t/d sulphuric acid plant treats roaster gases. Matte from the smelter is refined in Norway.
INCO Limited Sudbury, Ontario	Molten "blister" copper, nickel sulphide and nickel sinter for the company's refineries; nickel oxide sinter for market, soluble nickel oxide for market	3 650 000[2]	113 900*[3]	Oxygen flash-smelting of copper concentrate; converters for production of blister copper. Roasters, reverberatory furnaces for smelting of nickel-copper concentrate, converters for production of nickel-copper Bessemer matte. Production of matte followed by matte treatment, flotation, separation of copper and nickel sulphides, then by sintering to make sintered-nickel products for refining and marketing. Electric furnace melting of copper sulphide and conversion to blister copper.
Falconbridge Limited, Timmins, Ontario	Molten "blister" copper	600 000	70 000*	Mitsubishi-type smelting, separation and converting furnaces, acid plant and oxygen plant to treat continuous copper concentrate feed stream to yield molten 99% pure copper which is transported by ladles and overhead cranes to two 350 t anode furnaces.
Noranda Inc. Horne smelter, Noranda, Que.	Copper anodes	838 000	150 600[4]	One oxy-fuel fixed reverberatory furnace, one continuous Noranda Process reactor and five converters; oxygen for the reverberatory furnace and Noranda reactor are supplied by two plants with a combined total of 540 t/d. Continuous reactor modified to produce matte instead of of metal. Acid plant to be built and operational by end 1989.
Noranda Inc. Gaspé smelter, Murdochville, Que.	Copper anodes	325 000	65 300	One fluid bed roaster, one reverberatory furnace and two converters plus an acid plant. Treats Gaspé and custom concentrates.
Hudson Bay Mining and Smelting Co., Limited Flin Flon, Man.	Copper anodes	400 000	61 900	Five roasting furnaces, one reverberatory furnace and three converters. Company treats its own copper concentrate from mines at Flin Flon, Leaf Rapids and Snow Lake, as well as custom copper concentrates; zinc plant residues and stockpiled zinc-plant residues fed to reverberatory furnace.

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[1] Smelter output as reported in corporate annual reports or by personal communication; if no smelter data available, then refinery output shown and indicated by "*" following number. [2] Includes copper and nickel-copper concentrates. This capacity cannot be fully utilized owing to Ontario government sulphur dioxide emission regulations. [3] Includes a small tonnage of copper from INCO's Manitoba operations. [4] Strike from November 5 through year end.

TABLE 6. COPPER REFINERIES IN CANADA, 1987

Company and Location	Rated Annual Capacity	Output in 1986[1]	Remarks
	(tonnes)		
Noranda Inc. Division CCR East Montreal, Quebec	435 000	298 500[2]	Refines anodes from Noranda's Horne and Gaspé smelters, from the Flin Flon smelter and also from purchased scrap. Copper sulphate and nickel sulphate recovered by vacuum evaporation. Precious metals, selenium and tellurium recovered from slimes. Produces CCR brand electrolytic copper cathodes and cakes and billets. $19 million program to construct new slimes treatment plant announced in 1986 to be completed by mid-1988.
INCO Limited Copper Cliff, Ont.	180 000	113 900	Casts and refines anodes from molten converter copper from the Copper Cliff smelter; also refines purchased scrap. Gold, silver, selenium and tellurium recovered from anode slimes, along with platinum metals concentrates. Recovers and electrowins copper from Copper Cliff nickel refinery residue. Produces ORC brand electrolytic copper cathodes, and wirebars. Modernization program began in 1986.
Falconbridge Limited Timmins, Ontario	92 000	77 000	Molten copper from two 350 t anode furnaces is cast in a Hazelett continuous casting machine into continuous copper strip, then formed to 145 kg anodes in a blanking press. Spent and scrap anodes are remelted in a 40 t ASARCO shaft furnace. Cathodes formed in jumbo sized electrolytic tanks in a highly automated tankhouse. A decopperized precious metal slime is also marketed. Switch-over to stainless steel blanks for cathodes growth was completed in 1987.

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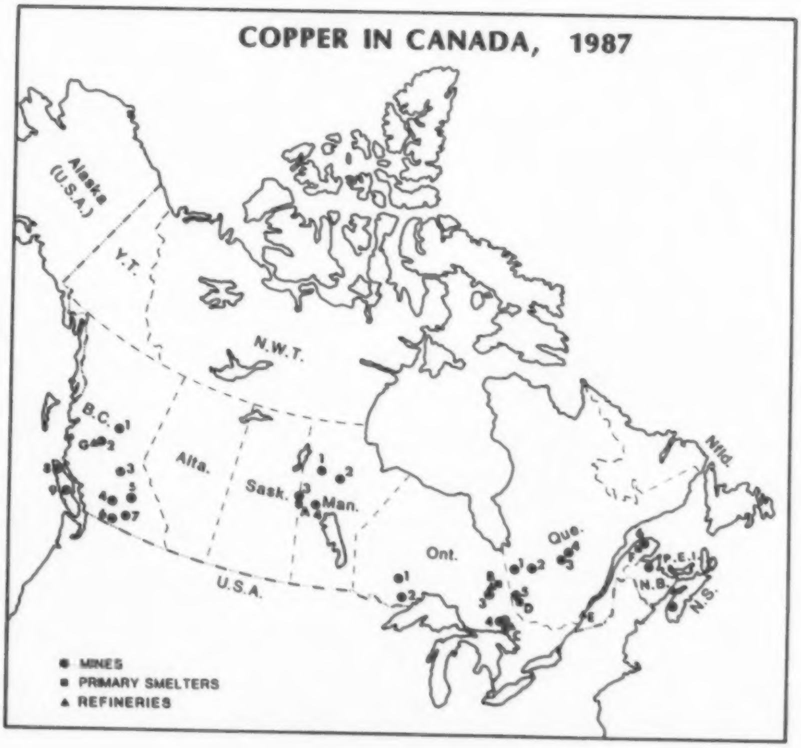
[1] As reported in corporate annual reports or as advised by company. [2] Operations affected by strike at CCR June 4-25, 1986 and strike at Horne smelter from November 5, 1986 through year end.

TABLE 7. MONTHLY AVERAGE COPPER PRICES, 1986 AND 1987.

	LME[1]		COMEX[2]	
	1986	1987	1986	1987
	(current US¢/lb.)			
January	64.3	61.1	65.3	60.8
February	63.8	62.6	63.9	61.7
March	65.5	66.5	66.0	63.6
April	65.1	67.3	63.8	62.4
May	64.4	69.0	62.7	66.5
June	64.1	71.3	62.6	69.9
July	61.0	76.9	58.9	76.2
August	59.1	79.7	57.6	77.6
September	61.1	82.1	60.7	81.0
October	59.7	89.2	59.2	83.0
November	59.1	114.5	58.9	103.9
December	60.6	130.1	60.2	127.5
Annual	62.3[3]	80.1	61.5	77.8

Source: Metals Week except LME 1986 annual average.

[1] LME Settlement Prices for Higher Grade Copper, 1985 and Jan. 1 - June 30, 1986, thereafter Grade A. [2] COMEX Copper Prices - first position. [3] The arithmetic average of the monthly prices for the highest grade sold calculated as US62.3¢/lb.


COPPER IN CANADA, 1987
Alaska (U.S.A.)
Y.T.
N.W.T.
B.C.
Alta.
Sask.
Man.
Ont.
Que.
Nfld.
P.E.I.
N.B.
N.S.
U.S.A.
● MINES
■ PRIMARY SMELTERS
▲ REFINERIES

PRODUCERS IN 1987

(numbers and letters correspond to those in map "Copper in Canada 1987")

British Columbia

1. Noranda Inc. (Bell mine)
2. Equity Silver Mines Limited
3. Gibraltar Mines Limited
4. Highland Valley Copper[1]
5. Afton Mines Ltd.
6. Newmont Mines Limited
7. Brenda Mines Ltd.
8. BHP-Utah Mines Ltd.
9. Westmin Resources Limited

Saskatchewan

Hudson Bay Mining and Smelting Co., Limited

Manitoba

1. Hudson Bay Mining and Smelting Co., Limited (Ruttan mine)
2. INCO Limited (Thompson mine)
3. Hudson Bay Mining and Smelting Co., Limited, Flin Flon area mines
4. Hudson Bay Mining and Smelting Co., Limited, Snow Lake area mines

Ontario

1. Mattabi Mines Limited
   Noranda Inc. (Lyon Lake)
2. Noranda Inc. (Geco mine)
3. Falconbridge Limited, Timmins
   Pamour Inc.
4. Falconbridge Limited, Sudbury area
   INCO Limited, Sudbury area

Quebec

1. Les Mines Selbaie
2. Noranda Inc. (Mattagami Lake mine)
3. Minnova Inc. Opemiska Division
4. Northgate Mines Inc.
   Campbell Resources Inc.
5. Audrey Resources Inc. (Mobrun mine)
6. Noranda Inc., Division Mines Gaspé

New Brunswick

Brunswick Mining and Smelting Corporation Limited

Nova Scotia

East Kemptville Tin Corporation Ltd.

SMELTERS

A. Hudson Bay Mining and Smelting Co., Limited
B. Falconbridge Limited
C. INCO Limited
   Falconbridge Limited
D. Noranda Inc.
F. Noranda Inc., Division Mines Gaspé

REFINERIES

B. Falconbridge Limited
C. Falconbridge Limited
   INCO Limited
E. Noranda Inc., Division CCR
G. Gibraltar Mines Limited

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[1] Highland Valley Copper is a partnership of Cominco Ltd. and Lornex Mining Corporation Ltd.

An inventory of undeveloped Canadian copper deposits is available in the publication "Canadian Mineral Deposits Not Being Mined in 1986", Energy, Mines and Resources Canada, Report MR 213, ISBN 0-660-12329-0.

For detailed production and ore grade information, refer to the table of Nonferrous Mines following the last commodity chapter.

FIGURE 1

LME COPPER PRICE - HIGHEST GRADE SOLD

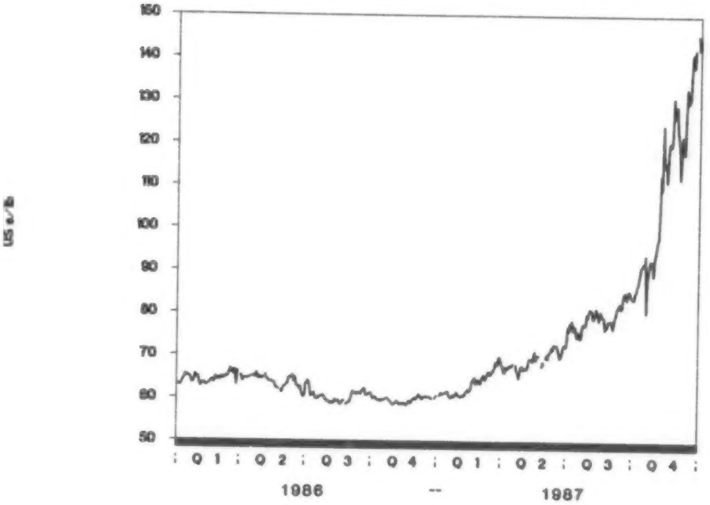


FIGURE 2

EXCHANGE STOCKS OF REFINED COPPER

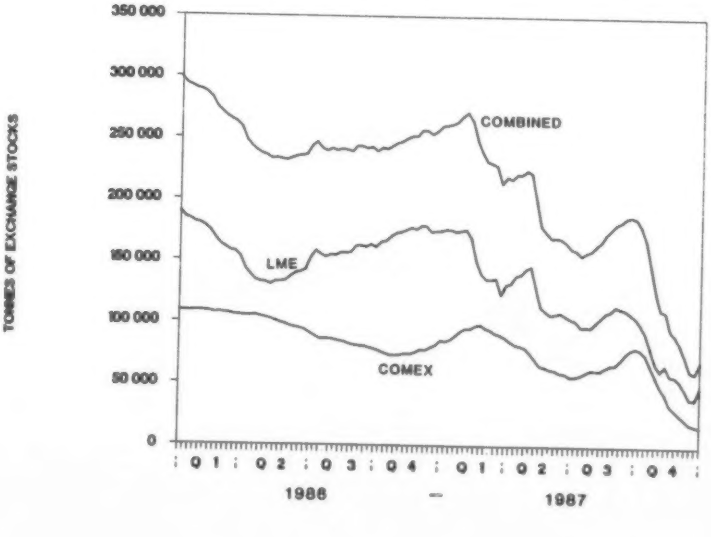


FIGURE 3

LME 3 MONTH COPPER CONTANGO

(BACKWARDATION IF NEGATIVE)

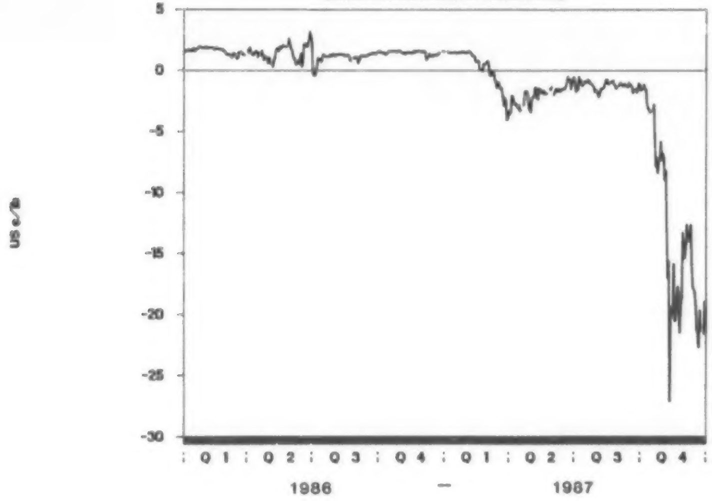
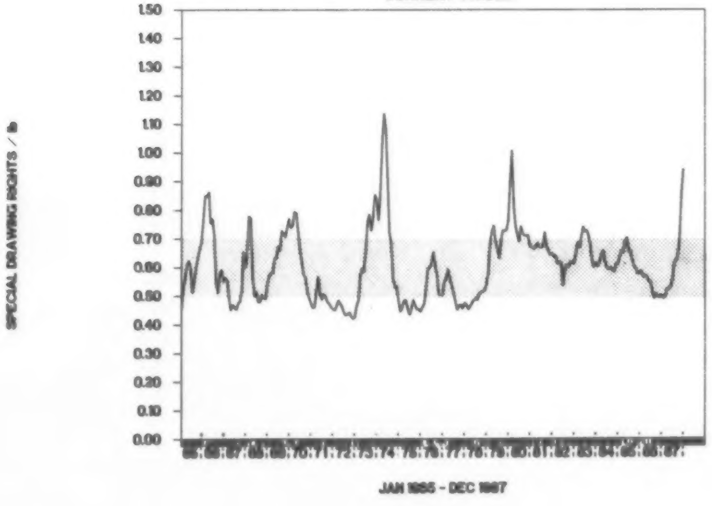


FIGURE 4

AVERAGE MONTHLY LME COPPER PRICES

CURRENT PRICES



Crude Oil and Natural Gas

R. THOMAS

Fluctuating oil prices in the international market continued to unsettle exploration and development activities in Canada. After a mid-December meeting of the Organization of Petroleum Exporting Countries, which failed to ensure strict adherence to production levels by OPEC members, the price of West Texas Intermediate crude fell to US$16.63 per barrel from about $17.40. This is an important crude oil type used as a "marker" affecting Canadian domestic prices. Since the drop in world prices in January 1986, and continuing throughout 1987, Canadian drillers had been recording well completion totals similar to the mid-1970s. Several large oil and gas projects that were planned in Canada prior to the drop in oil prices have been subject to some delay. Schemes being considered include the heavy oil upgrader at Lloydminster, Saskatchewan and the development of major oil and gas reserves in the Atlantic and Arctic offshores. While drilling in the frontier regions was reduced because of the completion of programs and price uncertainties, conventional operations in western Canada were also slowed down. For 1987, it is anticipated that the number of well completions may reach 6 700 wells. This amount would be slightly above the number recorded (6 400) in 1986. Last year, the aggregate metrage drilled reached almost 8 million m but it could possibly achieve some 8.5 million m in the year. Average well depths will again increase from over 1 200 m/well to almost 1 300 m/well.

EXPLORATION

During the first eleven months of this year, many of the leading indicators of exploration activity were well above those for the corresponding period of 1986. In some aspects, much of the work performed in exploration will have exceeded that for the previous year. In western Canada, revenues collected by the provinces from the sales of Crown Lands were in excess of $700 million, up from almost $300 million collected in 1986. Some 3.0 million hectares of land were acquired this year compared to 2.2 million ha sold in the previous year. Geophysical activity was up slightly in 1987 with an average 55 crews having been active whereas 53 crews were active each month during 1986. The number of well licences issued in western Canada was up considerably compared to the previous year. This was in response to federal and provincial drilling incentives. The number of drilling rigs available in Canada's fleet remained constant throughout the past year. After the record drilling year that was achieved in 1985 and the rapid oil price drop in 1986, rig utilization had not fully recovered due to the price instability. At the commencement of 1987, the rig utilization rate was well below past seasonal averages. It recovered in April and increased rapidly during the next several months to surpass the 1985 level in September and October. At the end of October, Alberta terminated its five-year royalty holiday on eligible wells, although the three-year holiday incentives were continued. During the first weeks of November, rig activity plunged dramatically to almost match that for 1986. It is expected that activity will again increase before the end of the year.

RESERVES

According to data released by the Canadian Petroleum Association, Canada's remaining established reserves of crude oil and equivalent gained some 17 million cubic metres (m^3) during the past year. The year started with 1 084.4 million m^3, an increase over the previous year's commencement of 1 067.8 million m^3. In the conventional regions, crude oil reserves fell by almost 35 million m^3 to a "remaining" value of 768.9 million m^3 (4.8 billion bbls). The quantities of pentanes plus had dropped by 14 million m^3 to 120 million m^3, or 756 million bbls.

The onshore and offshore frontier areas, outside of conventional provincial boundaries, recorded increases to crude oil and equivalent reserves. Gross additions to reserves were registered for crude oil in the Beaufort Sea that amounted to 65 million m^3,

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or 409 million bbls. The total volume of remaining revenues in the frontiers at the beginning of 1987 amounted to 175.4 million m^3 (1 104 million bbls.) of crude oil and 19.9 million m^3 (125 million bbls.) of pentanes plus.

In all areas of Canada, the remaining reserves of crude oil as of January 1, 1987 amounted to 944.4 million m^3 (5.9 billion bbls.) and the volumes of pentanes plus were 140 million m^3 (0.9 billion bbls.). This resulted in a combined total of 1 084.4 million m^3 (6.8 billion bbls.) of crude oil and equivalent.

Gross additions to reserves amounting to more than four times the production were added to liquefied petroleum gases (LPG's). The industry replaced almost 39 million m^3 (245 million bbls.) of ethane, propane and butanes. The net change in remaining established reserves was 30 million m^3 (189 million bbls.). The volumes of LPG's had risen to 199 million m^3 (1 252 million bbls.) from 169 million m^3 (1 063 million bbls).

Canada's conventional producing regions recorded a slight decline in the remaining established reserves of marketable natural gas. The reserves had dipped to 2 069 billion m^3 (73.4 trillion cu. ft.) from the previous level of 2 108 billion m^3 (74.8 trillion cu. ft.). While some provinces had shown minor increases or decreases, the Province of Saskatchewan recorded a major increase in its gas reserves over the past year, rising to more than 59 billion m^3 (2 176 billion cu. ft.) from almost 26 billion m^3 (916 billion cu. ft.).

The CPA registered a slight increase in the gas reserves for the frontier regions amounting to 264 million m^3, or some 9 billion cu. ft. The overall conventional and frontier reserves fell by about 1%, from 2.78 trillion m^3 (98.8 trillion cu. ft.) to 2.74 trillion m^3 (97.4 trillion cu. ft.).

PRODUCTION

The production of all liquid hydrocarbons is anticipated to have increased by 4% in 1987 compared to last year's production. This year, the average daily quantity was some 296 000 m^3/d, or 10 000 m^3 more than 1986. Preliminary statistics indicated that the production of conventional crude oil would have averaged 211 000 m^3/d during 1987, an increase of 3% over 1986. Much of the increase in conventional production occurred in Alberta, where the average daily output rose to 167 000 m^3 from 160 000 m^3/d. The combined production of synthetic crude oil from the Suncor and Syncrude plants averaged almost 31 000 m^3/d, up from the previous year's level of some 29 000 m^3/d. The production of synthetic crude accounted for almost 13% of the total crude output. Should planned expansions to the existing plants occur and the other "pilot" projects become commercial in the near future (based on improved crude oil prices), then the contribution of synthetic crude will have a significant impact on Canada's domestic requirements as conventional output diminishes due to natural reservoir depletion. There was an increase of 100 m^3/d, to 16 500 m^3/d, in the production of pentanes plus/condensate. Natural gas liquids (NGL's) rose by 5%, from 36 600 m^3/d to 38 500 m^3/d.

A decline of about 2% in domestic sales of natural gas was recorded during the past year, to 128 million m^3/d from 131 million m^3/d. Each of the three sectors (residential, industrial, and commercial) decreased their requirements by 1 million m^3/d. The industrial division continued to account for some 50% of domestic requirements with the remaining two demanding similar shares. Canada's exports of natural gas to the United States showed an increase of almost 8%, from 58 million m^3/d in 1986 to 62 million m^3/d in 1987. The decline in domestic sales was offset by the increase in exports, resulting in an overall increase from 189 million m^3/d to 190 million m^3/d.

RESOURCES

The Geological Survey of Canada continues to assess the probable volumes of crude oil and natural gas that remain to be discovered in the provinces and the territories. In one of its recent published reports, the GSC estimated that some 590 million m^3 of crude oil remained to be discovered in 4 000 individual pools dispersed throughout the Western Sedimentary Basin. According to the organization, Canada's oil potential ranges from 1 500 million m^3 to 9 000 million m^3 with an expected value at 50% to be 4 700 million m^3. The natural gas potential ranges from 4 300 billion m^3 to 18 000 billion m^3 with a 50% expectation of 9 500 billion m^3.

OIL SANDS PROJECTS

Oil sands projects fall under two categories: surface mining projects or in-situ bitumen projects.

(a) Surface Mining Projects

Surface mining of bitumen from oil sands deposits depends on stripping the surface burden above the bitumen bearing deposits. Therefore, this technology has a depth constraint for surface burden beyond which the operation becomes non-economical. The maximum depth of economic surface burden removal is calculated at 75 m. This means that less than 10% of the Athabasca oil sands deposits only are suitable for the application of this technology.

There are two important surface mining projects in the Athabasca oil sands deposit which are as follows:

(i) Syncrude Canada Ltd.

The company managed to decrease its unit operating cost to less than $\$100/m^3$ after the collapse of oil prices in 1986. Production averaged $20.7 \times 10^3 m^3/d$ in early 1987 and the company is expected to complete a \$1.2 billion expansion program in 1988, which would raise daily output to $25.4 \times 10^3 m^3/d$. The proponents are currently looking at either embarking on another expansion program (to be completed by the mid-1990s) which would add another $12 \times 10^3 m^3/d$ to the daily production or constructing another bitumen mining project. This new project is called the OSLO project which stands for "other six leases operation". These six leases are owned by six of the eight Syncrude partners (Canadian Occidental Petroleum Ltd. 25%, Esso Resources Canada Limited 25%, Gulf Canada Resources Limited 20%, Petro-Canada 15%, Alberta Oil Sands Equity 10% and PanCanadian Petroleum Limited 5%) and located east of the existing Syncrude project (across the Athabasca River) and could have a capacity of $12 \times 10^3 m^3/d$ as well. Either of these two alternatives would cost about \$4.0 billion.

(ii) Suncor Inc.

The company is almost 75% owned by Sun Company, Inc. of the United States and 25% by the Province of Ontario (through Ontario Energy Resources Ltd.). The company operates the second largest oil sands mining project in the Athabasca deposit. This project started in the late 1960s at a production level of $7.2 \times 10^3 m^3/d$ and is actually the first oil sands mining project in Canada. Suncor managed to cut down the unit operating cost to about $\$100/m^3$ after the collapse of oil prices in 1986. The company has announced lately that they plan to spend \$150 million to increase the upgrading capacity of the plant by 1 590 m^3/d; therefore the total daily output would reach $10.8 \times 10^3 m^3/d$ by the mid-1990s.

(b) In-Situ Bitumen Projects

Oil sands deposits that are too deep to produce by surface mining techniques are being developed through the use of in-situ techniques. Conventional vertical wells for steam injection, are drilled into the formations to heat the bitumen and lower its viscosity. After the heating, the well is put on production and the bitumen is pumped to the surface. Each well goes through several such cycles of steam injection or soak followed by bitumen production. This technology is referred to as the "Huff and Puff" method.

This technique is used in the Cold Lake and Peace River deposits where there are currently three commercial projects that produce about 85% of total bitumen production in Canada. These projects are as follows:

(i) Esso Cold Lake

This project is totally owned and operated by Esso Resources Canada Limited and produced over $12 \times 10^3 m^3/d$ in the third-quarter of 1987. The company completed this project in three stages (each stage composed of two phases with 3 000 m^3/d production), as an add-on to the three original pilot projects in the area.

Esso has announced lately their decision to proceed with the next two stages, which are expected to raise the production to over $18 \times 10^3 m^3/d$. Each stage is expected to cost about \$200 million and they are designed to be completed by 1989.

(ii) BP/Petro-Canada Wolf Lake

This project is owned 50/50 by BP Canada Inc. and Petro-Canada, with BP acting as the operator. The project is located in the Cold Lake deposits as well and produces about 1 300 m^3/d. The capital cost of the project was close to \$200 million and the companies have announced their intention to proceed this year with an expansion that would raise production to 3 660 m^3/d by 1989.

(iii) Shell Peace River

This commercial in-situ bitumen project is located in the Peace River deposits. The project is totally owned and operated by Shell Canada Limited. The project cost was about $200 million in 1986 and it produces 1 600 m^3/d. The company is studying the feasibility of expanding production to 6 400 m^3/d.

Other companies that have pilot projects in the Cold Lake deposits and are considering expansion to commercial projects at the level of 4 000 to 5 000 m^3/d are Amoco Canada Petroleum Company Ltd., Encor Energy Corporation Inc., Suncor Inc., and Westmin Resources Limited.

OUTLOOK

In late 1986, it was projected that the number of wells to be completed in Canada during 1987 might fall to 5 000 wells. This forecast was based upon the unstable low oil prices caused by an oversupply of crude in the international market. Several meetings among OPEC members failed to impose production cutbacks deemed necessary to increase oil prices. This resulted in the price continuing to fluctuate between US$18/bbl. and $20/bbl. throughout the year.

Effective April 1, 1987, the federal government introduced the Canadian Exploration and Development Incentive Program (CEDIP) which would make available to the service sector and the small oil and gas producers $350 million per year. This program is anticipated to generate over $1 billion in investment and some 20 000 person years of employment. It was expected that the package would also greatly enhance the number of wells to be drilled. Late-year drilling statistics indicate that 1987 well completions have surpassed those for 1986 by some 3%.

In addition to the federal incentives, the western producing provinces had assisted by introducing royalty relief to specific discoveries and a restructuring of existing royalty programs. Earlier in the year, Alberta had completely revised its natural gas royalty regime in consideration of negotiated prices agreed to by purchasers and sellers.

Almost every sector of the oil and gas industry, from explorationists through to producers, performed much better than in 1986. The turnaround was due to a greater improvement in the oil prices and investor confidence. The industry made higher expenditures for such categories as land, geophysical work, and drilling. In turn, it increased the produced volumes of crude oil, natural gas, and natural gas liquids. Increased shipments of domestic oil were recorded in Ontario and Nova Scotia (via tanker to Dartmouth). While much of Canada's liquid export volumes are sent to the United States, significant quantities are also shipped to Japan and Taiwan.

Export sales of natural gas, to the United States, increased during 1987 and this trend is anticipated to continue into 1988. The past couple of years in the United States has seen a marked decline in the drilling of natural gas wells and this may be a signal of future problems in domestic deliverability. Current production estimates, based upon existing remaining reserves, are assumed to be about ten years. This indicates a domestic requirement that will have to come from other available sources, should no new sizeable gas discoveries be made in the near future.

Oil analysts and trade associations are forecasting that 1988 will show a further improvement in Canada. This is based in part upon the industry's recovery late in the year. Large land acquisitions normally result in more wells being drilled. While Canada has sufficient quantities of natural gas for its domestic demand, a significant increase in exports could stimulate added exploration in gas necessary to discover and develop more reserves. A driving factor will be the price of crude oil and natural gas. Continued attempts are anticipated by OPEC members to curtail their production and stabilize oil prices. Once this is achieved, many high cost projects in Canada's western provinces and offshore frontiers will again proceed as planned.

FIGURE 1

CANADA'S PETROLEUM REGIONS

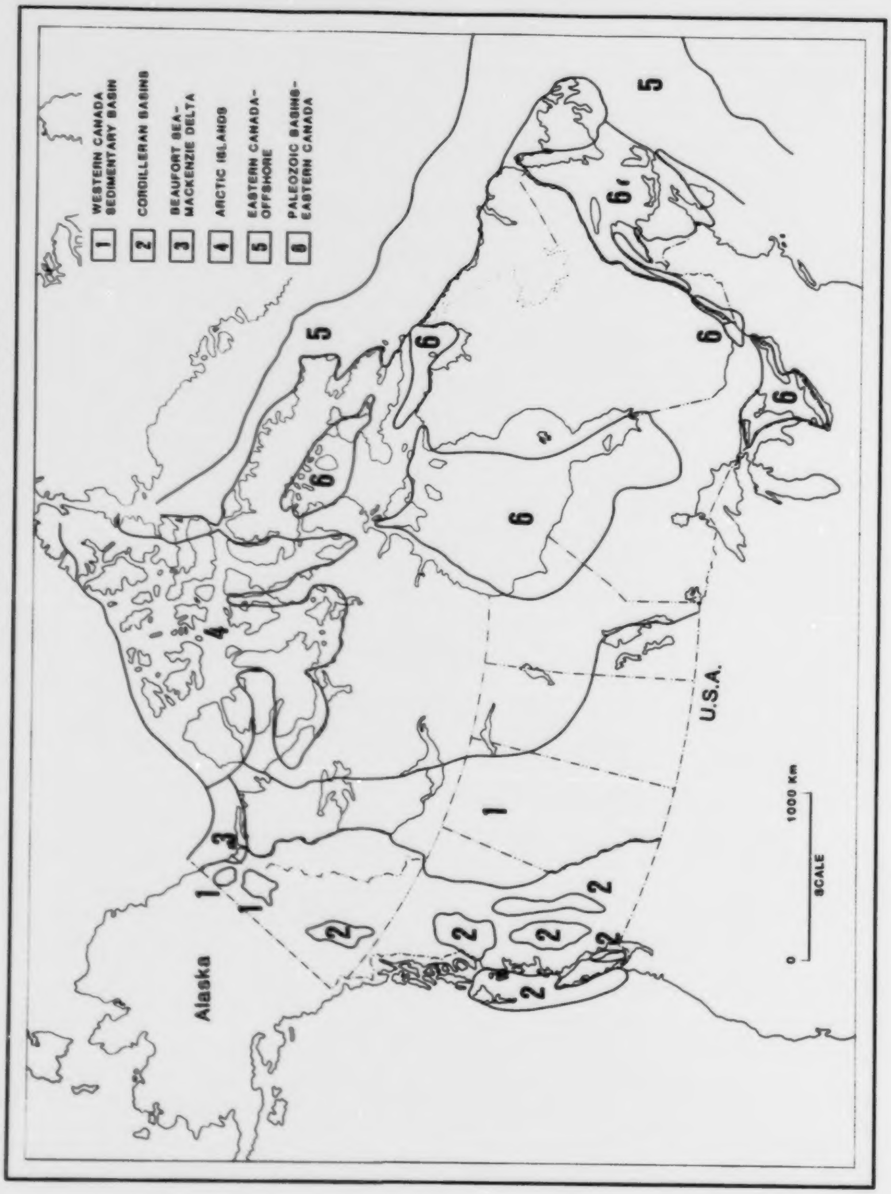

1 WESTERN CANADA SEDIMENTARY BASIN
2 CORDILLERAN BASINS
3 BEAUFORT SEA-MACKENZIE DELTA
4 ARCTIC ISLANDS
5 EASTERN CANADA-OFFSHORE
6 PALEOZOIC BASINS-EASTERN CANADA
Alaska
U.S.A.
SCALE
0
1000 Km

FIGURE 2

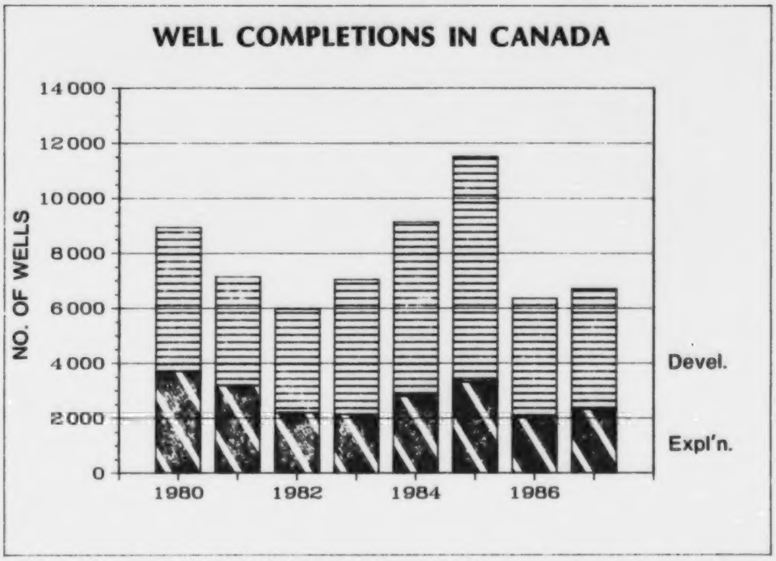
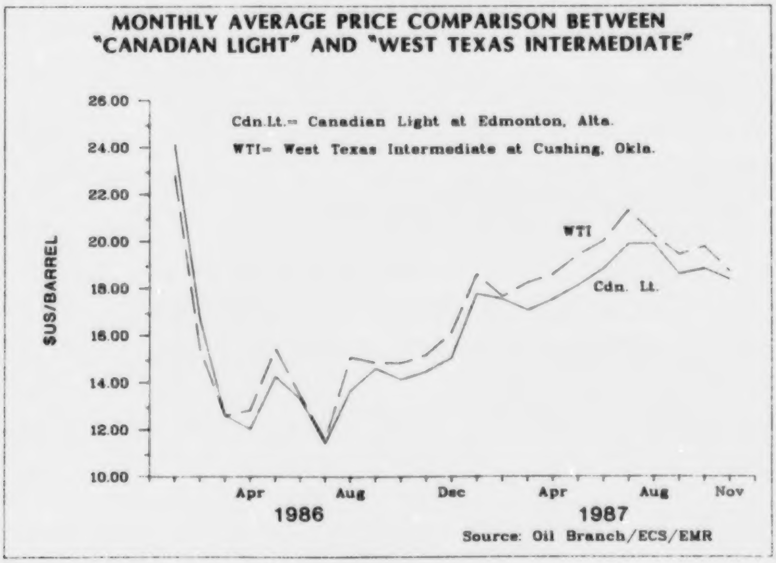


FIGURE 3



Source: Oil Branch/ECS/EMR

Ferrous Scrap

R. McINNIS

CANADIAN DEVELOPMENTS

During the first half of 1987, the Canadian market for ferrous scrap was slow, with prices and volume similar to those in the same period in 1986. Many processors were reluctant to buy all of the scrap that was available. In the second half of the year, prices began to climb rapidly. The weekly composite price for shredded steel, as quoted by the American Metal Market, rose from about US$85/t in May to US$132 in November, and ended the year at US$124. Canadian prices followed the United States lead but did not reach quite as high. Compared to the first quarter of 1987, prices in the final quarter increased by about 80% in the United States and 60% in Canada.

A number of factors contributed to this rapid price rise. In both Canada and the United States, the production of steel increased, partially due to a decline in the amount of imported steel. Also, many blast furnaces were down for repairs in the United States. With less pig iron production, more scrap was used by the integrated mills in their basic oxygen convertors and their electric furnaces. Most of the electric furnace mills in the United States and Canada operated at capacity. The fact that many steel companies had adopted just-in-time delivery for their scrap, as a common operating procedure, encouraged low inventories and left scrap users with no alternative to paying the going price, which added to the rapidity of the price increases. Furthermore, many new continuous casting machines had been brought on line, increasing the yield from molten steel and reducing the amount of home scrap available for use. Finally, the declining value of both the Canadian and American dollar, especially in the last quarter, helped to increase North American exports of ferrous scrap. Sales to developing Asian countries were very good. For some Canadian electric furnace steel companies, especially in western Canada, the export of local scrap to the United States and offshore resulted in supply problems and high scrap prices, which affected their profitability.

There was evidence of little change in the volume of scrap purchased by the Canadian steel industry in 1987. The steel mills purchased 2.84 Mt in the first 9 months of 1987, compared with 2.72 Mt in the same period of 1986. The total consumption of scrap by the steel industry, including own-generated scrap, was 5.28 Mt in the first 9 months. Ferrous scrap consumed by the steel industry in 1986 totalled 6.94 Mt.

Stelco Inc., Dofasco Inc., IPSCO Inc. and Atlas Steels division of Rio Algom Limited recently installed new continuous-casting equipment, which will reduce the amount of own-generated scrap produced in these mills. Since the amount of scrap used in the production of a tonne of steel is unlikely to diminish, Canadian steel companies can be expected to use larger tonnages of purchased scrap.

TRADE

Canada is more than self-sufficient in scrap, but there are regional differences in supply and consumption that result in significant trade between Canada and the United States. A high percentage of scrap, in excess of eastern Canadian needs, is exported to markets in the northeastern United States while the western Canadian market, which is generally deficient in local scrap, imports it from the American northwest and central regions.

The ferrous recycling industries in Canada and the United States share what they consider to be a single market. There are few restraints to the movement of scrap across the border and, consequently, prices in the United States have a major impact on those in Canada. During the last three years, 90% of Canadian scrap exports have gone to the United States. Exports helped support the domestic price, especially in the last half of 1986 and increases in scrap prices in the United States lead the Canadian price increases in 1987. Virtually all Canadian imports originate in the United States.

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As the recycling industry in Canada has grown, and as it has become more mechanized and efficient, more scrap has been available for export. The international market for scrap is very competitive and tends to fluctuate widely from year to year. Countries which have a history of buying significant volumes of Canadian scrap include South Korea, Spain, Italy and Japan.

CANADIAN INDUSTRY STRUCTURE

The Canadian ferrous scrap industry comprises approximately 600 firms. These companies collect, store and process the ferrous scrap for sale to the user industries. Most of these firms are small and are involved only in the collection of scrap. Dealers who are also involved in the sorting and storage of scrap are fewer in number, while those who engage in capital intensive processing comprise the smallest group. Scrap processing requires heavy equipment such as mechanical shredders, shears, presses and bundlers. This segment of the scrap industry produces the grades and types of scrap needed by the steel mills. A new competitively sized processor would have to spend in excess of $10 million on capital equipment today.

Autobody shredding equipment represents a significant capital investment in the scrap industry. There are presently 15 shredders installed in Canada, which in aggregate have the capacity to process about 1.3 million cars per year.

Statistical Process Control has been implemented at most of the large processors in response to market demand for higher quality purchased scrap.

Scrap is such an important raw material that it is common practice for Canadian steel producers to hold equity in scrap processing companies in order to reduce the risk of supply problems, and to assure quality control of the scrap to meet their needs.

SCRAP CLASSIFICATION

The producers of ferrous scrap describe unprocessed scrap by its origin. Home (own-generated) scrap is produced in the manufacture of steel mill products, whereas prompt industrial scrap is generated by the secondary manufacturing industry and obsolete scrap comes from discarded machinery, equipment and structures.

Prompt and obsolete scrap is generally processed by the recycling industry and is made into a number of products for which standards have been written by the Canadian Association of Recycling Industries.

Scrap classification is based on factors such as size, type of material, cleanliness, and residual alloying elements. The most common grades are as follows:

Scrap Products[1]

Class No.	Grade and Type
100	No. 1 Heavy Melting Steel
101	No. 1 Hydraulic Bundles
102	No. 2 Bushelling - Prepared
103	No. 2 Heavy Melting Steel
104	Plate and Structural Steel
105	No. 2 Hydraulic Bundles
106	Hydraulic Silicon Bundles
107	No. 2 Bushelling - Prepared
108	No. 1 Bushelling (Clips)
109	Short Shovelling Steel Turnings (Crushed)
110	Machine Shop Turnings
111	Mixed Turnings and Borings
112	Cast Iron Borings
113	No. 1 Shredded Scrap
114	No. 2 Shredded Scrap
115	Briquetted Steel Turnings - Alloy Free
116	Briquetted Steel Turnings - Alloyed
117	Foundry Steel

[1] From Canadian Association of Recycling Industries.

PRICES

The composite price, in U.S. dollars per delivered long ton of shredded steel scrap, as quoted by the American Metal Market, averaged slightly more than $85/t during the first half of 1987. In July, prices began to increase, reaching a high of $132 in October. The price at year-end was $124.

USES

Most ferrous scrap is used in electric furnace steel mills and integrated mills for the production of steel. The foundry industry is the second largest market for scrap. Minor markets include the production of iron powders, sinter, ferroalloys and abrasives.

Scrap used in the electric furnace steel industry must be carefully selected in order to minimize the melting time and the consequent cost of energy per tonne, and to maximize the furnace productivity. Depending on the grade of scrap, it can take from 1 100 to 1 200 kg of scrap to produce 1 000 kg of steel. Tramp elements in scrap are a larger problem in electric furnaces than in integrated mills because there is less opportunity to remove them by oxidation and slagging or to dilute them in the melt by addition of pig iron. Certain elements like tin are more difficult to remove than others. Thus, scrap grades low in tramp elements are preferred by electric furnace mills.

Open-hearth and basic oxygen furnaces (BOF) provide more scope for steel refining. In these, scrap can be added at about 50% and 30% of the respective charges. In a BOF, a small amount of scrap is necessary to absorb the energy released when the carbon in the molten iron is removed by oxidation. This same energy can be used to melt up to 30% scrap. Apart from the saving in energy, ferrous scrap is usually much cheaper than iron produced in a blast furnace. Therefore, integrated mills focus some of their research effort on optimizing the amount of scrap charged to their steel furnaces.

On balance, integrated steel operations have more flexibility than electric furnaces with respect to the percentage of scrap in furnace feed and they are also less dependent on scrap availability and price. In periods of high demand, when integrated mills operate near capacity, scrap usage is often maximized to increase steel production even if scrap prices are high. The reverse situation may apply when steel demand is low and scrap use is governed by a minimum blast furnace operating rate. In this case it would be necessary to restrict scrap use to avoid over-production even if scrap were available at a very low price.

The ratio of purchased to own-generated scrap in an integrated steel mill varies from year to year. This ratio for the Canadian steel industry was 0.93 in 1984, 1.02 in 1985, 1.10 in 1986 and 1.17 in 1987. The ratio is partly a function of the price of scrap and partly dependent on other factors. For example, in times of low steel demand, steel mills may use iron produced in their operating blast furnaces in place of purchased scrap to avoid banking the blast furnaces. Also, the practice can be used to maintain iron ore and coal consumption near contracted levels. Such a decision may have been made in 1982 when the amount of purchased scrap that was used per tonne of steel was unusually low, even though the price of scrap was especially depressed. The expanding use of continuous casting equipment will influence this ratio during the next few years.

In the case of the electric furnace steel industry, the price-demand relationship is much more direct because ferrous scrap is the principal raw material. Consequently, electric furnace mills can produce steel at considerably less cost than integrated mills in periods of low steel demand and low scrap prices, allowing them to capture market share and remain profitable. Many companies in this industry have been installing ladle refining facilities to improve the quality of their products, thereby allowing them to compete with the integrated mills over a larger product range.

The increasing use of continuous casting and improvements in basic oxygen furnaces (BOF), such as the advent of Lance Bubbling Equilibrium (LBE) equipment, will tend to reduce the levels of own-generated scrap and increase the demand for purchased scrap.

QIT-Fer et Titane Inc., which now makes steel from pig iron that it produces as a coproduct with titanium slag in its electric furnace smelting facilities at Tracy, Quebec, is a potential scrap customer. This company has the capacity to produce 400 000 t/y of steel billet and it could use up to 120 000 t of scrap to make this volume of steel. However, the present intention is to make high quality billet using only its own pig iron.

OUTLOOK

The scrap industry anticipates that prices will hold at high levels for the first quarter of 1988 and probably for the entire year. This scenario is based on the premise that supplies of scrap will likely remain tight in Canada, because of fundamental conditions. For example, the demand for steel is expected to remain high and scrap inventories will be rebuilt, especially by those companies that ran out of scrap in 1987. Also, four new continuous casting machines began operating in 1987 and a fifth is scheduled for 1988.

The high price and physical shortage of scrap in 1987 revived interest in direct reduced iron (DRI) as a scrap substitute. This interest is also due to the demand for higher quality and cleaner steels, which has resulted in proportionately higher prices for premium grades of scrap. DRI is uncontaminated, of consistent quality and, thus, can be used to dilute the unwanted tramp elements that occur in scrap.

Integrated and electric furnace mills are experiencing rapid technological change, which will have a long-term impact on the scrap market. Recent research and development efforts have focused on increasing the amount of scrap that can be used in the oxygen steel converter. New developments include systems in which fuel and oxygen are blown into the converter to preheat the scrap charge, and Lance Bubbling Equilibrium (LBE) equipment in which inert gases are blown through the bottom of a BOF-type vessel. The more efficient mixing created by the LBE system results in higher yields, increases the amount of scrap that can be charged, and improves the quality of the steel. LBE equipment is being installed in a number of Canadian BOF's.

The market for scrap and the amount of scrap purchased by integrated mills also vary with the amount of scrap that is produced within the steel plant. The introduction of continuous casting has considerably reduced the ratio of home to purchased scrap. Yields from molten crude steel to finished steel can increase by almost 20% when continuous casting is used instead of ingot casting.

Technical developments in the electric furnace mills have centred on the treatment of the steel in a holding vessel, a process called ladle metallurgy. This technique frees the furnace for more production and allows a final treatment to improve the chemistry of the steel. The improved products will allow electric furnace mills to capture a greater share of the steel market and thereby increase the demand for scrap. Another technology that could be rapidly adopted by the industry is the continuous casting of thin slab that could be easily rolled into sheet products, a product that can be currently produced only by integrated mills. Nucor Corp. of Charlotte, N.C. began construction of a mill based on the "thin slab casting" technology. Production is scheduled for May or June of 1988.

Scrap usage is expected to increase by approximately 3% in 1987. In the medium-term to 1990, usage should increase 4% to 5%/y as more continuous casting equipment is added and a greater percentage of the steel made in North America is produced in electric furnaces. The growth rate after 1990 is forecasted to slow to approximately 2%/y.

The anticipated rising demand for higher quality scrap, especially in terms of low levels of tramp elements and more desirable product forms, will likely require the installation of more sophisticated process equipment. This could include x-ray spectrometers to analyze scrap, mechanical separators, high pressure bailers and briquetting machines for the production of high density product, and better shredders that would improve the separation of ferrous metal from nonferrous metals and nonmetallic components.

TABLE 1. CANADA, IMPORTS OF STEEL SCRAP, BY PROVINCE OF ENTRY, 1984-86

		1984		1985		1986P	
		World	United States	World	United States	World	United States
Nova Scotia	tonnes	-	-	-	-	38	38
	$000	-	-	-	-	9.7	9.7
New Brunswick	tonnes	5	5	109	109	65	65
	$000	374	374	19	19	6.8	6.8
Quebec	tonnes	28 216	28 199	27 548	27 368	31 770	31 757
	$000	5 846	5 843	2 897	2 727	3 521	3 519
Ontario	tonnes	430 038	429 980	402 019	402 015	274 054	273 988
	$000	41 697	41 673	38 691	38 691	28 458	28 374
Manitoba	tonnes	44 998	44 998	41 886	41 886	21 568	21 568
	$000	4 135	4 135	3 420	3 420	1 420	1 420
Saskatchewan	tonnes	185 759	185 759	83 785	83 785	42 006	42 006
	$000	15 798	15 798	6 888	6 888	3 620	3 620
Alberta	tonnes	40 868	40 868	19 919	19 919	19 939	1 875
	$000	4 212	4 210	1 830	1 830	19 939	1 875
British Columbia	tonnes	2 186	2 186	2 413	2 413	5 369	5 369
	$000	995	495	265	265	446	446
Total	tonnes	732 084	731 996	577 678	577 499	394 809	394 731
	$000	72 684	72 655	54 010	53 841	39 356	39 270

Source: Statistics Canada.
P Preliminary; - Nil.

TABLE 2. CANADA, EXPORTS OF STEEL SCRAP, BY PROVINCE OF LADING, 1984-86

		1984		1985		1986P	
		World	United States	World	United States	World	United States
Newfoundland	tonnes	-	-	3 827	-	-	-
	$000	-	-	553	-	-	-
Nova Scotia	tonnes	-	-	32 695	8 147	1 575	1 563
	$000	-	-	4 112	1 222	247	244
Prince Edward Island	tonnes	-	-	-	-	104	104
	$000	-	-	-	-	15	15
New Brunswick	tonnes	221	171	2 811	2 811	10 669	2 883
	$000	49	46	388	388	1 472	361
Quebec	tonnes	199 055	15 914	245 469	17 491	176 250	25 922
	$000	20 121	2 029	29 778	2 068	15 132	3 239
Ontario	tonnes	376 182	348 002	414 688	373 167	521 554	466 004
	$000	34 288	30 994	38 149	32 421	49 025	42 984
Manitoba	tonnes	1 171	1 171	991	991	5 248	5 248
	$000	205	205	93	93	813	813
Saskatchewan	tonnes	-	-	-	-	86	26
	$000	-	-	-	-	86	26
Alberta	tonnes	832	832	583	170	299	168
	$000	90	90	193	24	100	63
British Columbia	tonnes	140 012	139 657	108 746	101 795	8 133	77 259
	$000	14 485	14 399	10 886	9 842	10 886	93 792
Yukon	tonnes	-	-	230	230	1 429	127
	$000	-	-	41	41	143	7
Total	tonnes	717 455	505 746	810 040	504 802	811 007	579 279
	$000	69 237	47 763	84 193	46 100	77 860	55 864

Source: Statistics Canada.
P Preliminary; - Nil.

TABLE 3. CANADA, EXPORTS OF STAINLESS STEEL SCRAP, BY PROVINCE OF LADING, 1984-86

		1984		1985		1986P	
		World	United States	World	United States	World	United States
Newfoundland	tonnes	–	–	–	–	–	–
	$000	–	–	–	–	–	–
Nova Scotia	tonnes	100	20	74	–	211	–
	$000	80	13	67	–	236	–
New Brunswick	tonnes	332	23	120	–	115	27
	$000	337	23	105	–	167	79
Quebec	tonnes	3 221	767	4 301	1 507	3 601	2 004
	$000	2 906	710	3 725	1 294	2 769	1 302
Ontario	tonnes	17 364	6 240	21 850	16 775	20 594	7 103
	$000	15 914	4 208	94 973	6 479	17 456	4 948
Manitoba	tonnes	182	166	352	205	225	169
	$000	100	87	263	130	225	169
Saskatchewan	tonnes	–	–	–	–	4	8
	$000	–	–	–	–	4	8
Alberta	tonnes	46	46	2	–	140	163
	$000	28	28	60	–	146	171
British Columbia	tonnes	1 548	591	1 520	368	477	287
	$000	1 068	233	1 194	143	2 159	1 583
Total	tonnes	22 793	7 854	28 218	11 577	27 104	10 026
	$000	20 433	5 302	22 190	8 046	22 534	6 934

Source: Statistics Canada.
P Preliminary; – Nil.

TABLE 4. CANADIAN CONSUMPTION OF IRON AND STEEL SCRAP

	1977	1978	1979	1980	1981	1982	1983	1984^r	1985^r	1986P	1987^e 9 months
	(000 tonnes)										
Used in steel furnaces	5 708	7 076	7 250	7 501	6 845	5 492	6 449	7 383	7 034	6 948^r	7 100
Used in iron foundries	524	518	604	470	500	448	416	552	551	595^e	..
Other[1]	938	865	868	770	926	837	475	500	550	625	..
Total	7 170	8 459	8 722	8 741	8 271	6 777	7 337	8 435	8 135	8 168	7 100

Sources: 1982 Annual Census of Manufactures. 1983 and 1984 Catalogue 41-001 Primary Iron and Steel.

[1] Includes mainly steel pipe mills, motor vehicle parts, and railway rolling stock industries.

P Preliminary; ^{r} Revised; ^{e} Estimated; .. Not available.

TABLE 5. AUTOMOBILE SHREDDERS IN CANADA

Company	Location	Capacity (tonnes/month)
Intermetco Limited	Hamilton, Ontario	8 000
United Steel and Metal, division of USACO Limited	Hamilton, Ontario	5 000
Bakermet Inc.	Ottawa, Ontario	8 000
Industrial Metal, division of Co-Steel Inc.	Toronto, Ontario	10 000
Zalev Brothers Limited	Windsor, Ontario	8 000
Sidbec-Feruni inc.	Contrecoeur, Quebec	8 300
Fers et Métaux Recyclés Ltée	Longueuil, Quebec Laprairie, Quebec	4 000 4 000
Associated Steel Industries Ltd.	Montreal, Quebec	8 000
Native Auto Shredders	Regina, Saskatchewan	6 000
Cyclomet	Moncton, New Brunswick	4 000
Navajo Metals, division of General Scrap & Car Shredder Ltd.	Calgary, Alberta	3 000
Stelco Inc.	Edmonton, Alberta	8 000
Richmond Steel Recycling Limited	Richmond, British Columbia	5 800
General Scrap & Car Shredder Ltd.	Winnipeg, Manitoba	3 000
Total		85 100

Fluorspar

M. PRUD'HOMME

Fluorspar is the commercial name for fluorite, a calcium fluoride mineral (CaF_2) which occurs most commonly as a vein-mineral usually associated with quartz, calcite, dolomite or barite. Fluorite is an isometric mineral which exhibits a wide range of colours from colourless to yellow, blue, green, rose and brown. It has a vitreous luster and a hardness of 4 on the Moh's scale. Fluorite is the most important source of fluorine. Fluorspar is used in the manufacture of hydrogen fluoride (HF or hydrofluoric acid), in various metallurgical processes and in ceramic wares. Fluorite deposits are widely distributed and are mined on all continents.

Cryolite is a sodium aluminum fluoride which is widely distributed in nature. Natural cryolite has been found in important quantities at only two localities, near Miask in the U.S.S.R. and near Ivigtut in Greenland where it was mined for several years up to the mid-1970s. Natural cryolite is now rare and has been largely replaced by synthetic cryolite obtained from hydrofluoric acid.

PRODUCTION IN CANADA

Fluorspar is the principal source of the element fluorine. It occurs in many geological environments from low-temperature fracture fillings to high-temperature emplacements and, as a result, it is not restricted to any particular geological province in Canada. In fact, fluorspar is known to occur in all physiographic provinces, with the exception of the interior plains.

In January 1987, Minworth Ltd. of London, England, commissioned its fluorspar operation at St. Lawrence, Newfoundland. St. Lawrence fluorspar made its first shipment to the United Kingdom in late June; further sales followed for delivery in the United States. Fluorspar reserves are estimated at close to 4.3 Mt of fluorite ore grading between 47-67% CaF_2. The ore is contained in sub-vertical veins 4-5 m in width found in granitic material. Fluorspar ore is mined at the Tarefare vein open-pit and Blue Beach North underground mine. Development work was carried out at the old underground Blue Beach South mine and Blue Beach North subsurface vein while exploration work was conducted at the Blow-out and Rosey Ridge veins. Underground and open-pit material feeds a 200 t/d flotation plant for beneficiation to produce acid grade spar with 97-98% CaF_2, maximum 1.0% SiO_2 and 1.0% $CaCO_3$ with very low sulphide and arsenic content.

Following fine tuning in late spring, the plant operated on the basis of 3½ days/week during the summer, with employment reaching up to 75 workers. Construction of a wharf extension and warehouse storage was completed. Lower levels of commercial activity in early winter resulted in putting the whole operation on maintenance. However, operations are expected to resume in early January when deliveries pick up again.

Norbert Blechner of AIO Corporation, USA, has been appointed as the sales agent for marketing St. Lawrence material both in the United States and Canada.

General Chemical Canada Ltd. imports acid-grade fluorspar mainly from Mexico and Spain for the production of hydrofluoric acid (HF) at Amherstburg, Ontario. The plant has a production capacity of 52 000 t/y of HF. Most of the acid is exported and utilized in the manufacture of fluorocarbons. General Chemical at Amherstburg, and Du Pont Canada Inc. at Maitland, Ontario are the only companies that manufacture fluorocarbons in Canada.

The Alcan Aluminum Limited has commissioned the largest aluminum trifluoride (AlF_3) plant in North America in Jonquière, Quebec. The $135 million plant has a production capacity of 40 000 t/y of AlF_3, and replaces an obsolete plant. The new plant employs 68 people and close to two

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thirds of the AlF_3 produced will be used by Alcan smelters in Quebec and Kentucky; the remainder will be sold to Reynolds Aluminum Company of Canada Ltd. and the Aluminerie de Bécancour Inc. (A.B.I.). Alcan currently imports all of its fluorspar from Morocco, Spain, China and Italy. Modernization of its electrolysis processes will result in a significant 32% reduction in the amount of fluorspar required to produce aluminum. Alcan will be recycling fluorine emissions to simultaneously reduce the impact on the environment and optimize its consumption of fluorspar.

Eaglet Mines Limited of Vancouver shelved its project for developing an underground fluorspar mine near Quesnel Lake where 24 Mt of fluorspar ore grading 11.5% CaF_2 have been delineated.

MARKETS AND USES

Fluorspar is marketed in three grades according to end-use: acid grade, containing a minimum of 97% CaF_2; metallurgical grade, containing a minimum of 60% effective CaF_2; and ceramic grade No. 1 containing 95 to 96% CaF_2; and No. 2 containing 85 to 90% CaF_2.

Acid grade. Roughly 40% of the world's fluorspar requirements are for acid grade used in the manufacture of hydrofluoric acid. Hydrofluoric acid has a variety of uses, but by far the most important is in the chemical and aluminum industries, which together account for some 80% of consumption.

Between 50 and 60% of hydrofluoric acid is consumed in the manufacture of chlorofluorocarbons (CFC). Fluorocarbons are used as refrigerants (CFC 11 and 12) for industrial and consumer equipments and air conditioning units, and as blowing agents in plastic foam; as sterilisants (CFC 12) for medical supplies and as solvents (CFC 113) for microelectronic circuitry.

Long-life CFCs, particularly the fully halogenated compounds 11, 12 and 113, have been identified by scientists as potential threats to the environment. These fluorocarbons are believed to modify the concentration and the distribution of the stratospheric ozone layer which protects the earth from solar ultraviolet radiations.

In September, member countries of the United Nation Environment Program agreed in Montreal on a Protocol on substances that deplete the ozone layer. A group of 40 nations signed an international convention proposing controls and limits on production, consumption and trade for fully halogenated CFCs (11, 12, 113, 114, 115) and halons. Ratification of the Protocol is expected in 1988 for its implementation starting in early 1989.

About 15% of all hydrofluoric acid is used by the aluminum industry. Hydrofluoric acid is used in the manufacture of synthetic cryolite, an essential cell ingredient for fluxing in the electrolytic reduction of alumina to aluminum. The acid is also used to produce aluminum trifluoride (AlF_3) which lowers the melting point of the electrolyte in the refining process.

Fluorspar is also used in uranium refining, in the manufacture of alkylate for high octane fuel, in steel pickling, enamel stripping, glass etching and electroplating.

Metallurgical grade. About half of the world's fluorspar production is consumed as a metallurgical fluxing agent (metspar), primarily in the manufacture of steel where it is used to remove impurities during melting and also to improve separation of metal and slag in the furnace by increasing the fluidity of the slag.

More fluorspar is being recycled because of environmental constraints which are forcing plants to reduce emissions; this also tends to promote the use of substitutes such as olivine and dolomitic limestone in some countries.

Ceramic grade. Ceramic grade fluorspar is used as flux and as an opacifier in enamels, flint glass, white or opal glass. It is also used in the manufacture of glass fiber insulation.

TRADE AND CONSUMPTION

In 1986, fluorspar imports in Canada rose 46% to 164 114 t. Imports were mainly shipped to Ontario (66%) and Quebec (27%). For the first nine months of 1987, imports amounted to 67 853 t and were from Mexico (36%), Morocco (17%) and China (14%). The unit value of imported fluorspar increased 6.3% to $147.44 over 1986. All hydrofluoric acid imports originated from the United States for delivery mainly in Ontario.

Consumption of fluorspar in Canada is in the order of 170 000 t/y of which close to 90% is acid grade spar for use in the production of fluorocarbons and aluminum.

WORLD PRODUCTION

In 1986, world production of fluorspar remained stable at 4.87 Mt. Mexico, the largest producer, accounts for 16% of total world production, followed by Mongolia with 15%, China with 13% and the U.S.S.R. with 11%.

Acid grade fluorspar amounted to about 2 095 000 t and was primarily produced by Mexico (22%), South Africa (16%), the U.S.S.R. (15%) and Spain (14%).

United States. Estimated production of fluorspar in 1987 increased by 2.5% to 72 560 t. Imports of acidspar and metspar remained fairly stable totalling 500 000 t while imports of hydrofluoric acid and cryolite rose 24% to 209 000 t of fluorspar equivalent. Apparent consumption increased by 13% to 587 000 t due to improved market conditions in aluminum and chlorofluorocarbons. Production of by-product fluosilicic acid rose 30% to 118 000 t due to a higher operating rate in the domestic fertilizer industry. Acidspar requirements are essentially imported from Mexico (45%), South Africa (42%), Spain (7%), Morocco (4%) and Kenya (2%). Acidspar is used for the production of hydrofluoric acid for fluorocarbons (41%), aluminum (31%), petroleum products (4%), stainless steel products (4%) and uranium concentrate (4%).

Diversified Minerals Corp. announced its intention to reactivate an old fluorspar mine and facilities located in Livingstone County near Paducah, Kentucky. The tentative start-up date for the 63 000 t/y processing plant has been set for early 1988 with a preliminary production in the range of 32-45 000 t/y. Reserves have been estimated at 1.8 Mt of ore grading 50% fluorite. The company expects to market very high purity acid grade concentrate and by-product metallurgical grade in the region.

Brazil. Mineraçao de Rey, a subsidiary of E.I. du Pont de Nemours and Company in Brazil, will commission a new fluorite mine at Cerro Axul in Parana State, during 1988. The US$14 million project comprises an open-pit mine and a 60 000 t/y processing plant. The capacity of production for acid grade fluorspar is in the order of 50 000 t/y. Reserves have been estimated at 2.8 Mt of ore grading 60% fluorite. The acid grade spar concentrate will be sold mainly to the domestic chemical industry.

Namibia. Okorusu Fluorspar Pty Ltd. began production of acid grade fluorspar at its 55 000 t/y plant at Okorusu Mountain, Namibia. Total in-situ reserves are estimated at 6.04 Mt with an average grade of 56% CaF_2. Okorusu Fluorspar filtercake concentrates average 98% CaF_2. Sales will be exclusively handled by Heliconores of London.

India. Gujarat Mineral Development Corp. (GMDC) announced its intention to proceed with the expansion of its fluorspar operation at Kadipania in the Baroda District. The capacity of production for both metspar and acidspar is planned to increase from 20 000 t/y to 50 000 t/y by the end of 1989.

United Kingdom. Deepwood Mining Co. Ltd. announced plans to construct a 50 000 t/y processing plant to produce acid grade fluorspar from its fluorspar open-pits near Derbyshire. Fluorspar concentrates are expected to average a minimum of 99% CaF_2 with no arsenic and phosphorus and will be sold on both the domestic and western European markets.

OUTLOOK

An oversupply situation dominates the fluorspar market as new production capacity is being developed; however, the market for acidspar in North America is registering small gains due to a growing demand for hydrofluoric acid.

The simultaneous increases in capacity and demand will likely result in stable prices for acidspar although quality and contract specifications may result in a higher pricing structure.

Demand for acidspar should continue to be dependant on the consumption of hydrofluoric acid for the production of aluminum and fluorocarbons.

Demand for fluorocarbons had been forecast to grow steadily but the industry is now confronted with some uncertainity as a result of the UNEP protocol and it associated limits on production and consumption. CFC producers and consumers are persistently carrying research and development work for alternatives; they are actively examining a number of avenues such as the production of a new generation of fluorocarbon, the use of other chemicals such as hydrocarbons, the use of new finished products such as paper board instead of expanded foam products, and the development of technologies for recycling. However, the development of new CFCs is the most appealing option for acidspar producers since the discard of the chlorine component could result in the production of CFCs with a higher fluoride content.

The upturn in the aluminum industry is likely to continue in the short term and will result in increased consumption of cryolite and aluminum trifluoride, reflecting higher demand for acidspar. Growth in the aluminum industry may help offset the eventual losses in the consumption of acidspar by the fluorocarbons industry. In the medium term, the outcome of R&D on fluorocarbons with high fluoride content will have an important influence on the future of the world acidspar industry.

PRICES

	1985	1986	1987
Fluorspar		(US$/tonne)	
Mexico, f.o.b. Tampico			
Acid grade, filtercake	110	110	110
Metallurgical grade	72-77	72-77	50
South Africa, f.o.b. Durban			
Acid grade, dry basis	110	100	100-110
United States, f.o.b. Illinois			
Acid grade, bulk	185-190	168-173	168-173
Ceramic grade, (95-96% CaF_2)	170-187	170	170
Ceramic grade, (88-90% CaF_2)	100-110	100	100
Hydrofluoric Acid		(C$/kg)	
Canada, f.o.b. Amherstburg			
Anhydrous 100%, tanks	2.04	2.04	2.04
Aqueous 70%, tanks	1.60	1.60	1.60
		(US$/lb.)	
United States, f.o.b. plant			
Aqueous 70%, tanks	0.43	0.43	0.43
Anhydrous 100% tanks	0.6875	0.6875	0.6875

Sources: Industrial Minerals; Engineering and Mining Journal; Corpus Chemical Report; Chemical Marketing Reporter.
F.o.b. Free on board.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
CANADA					
29600-1	Fluorspar	free	free	free	free
UNITED STATES					
522.21	Fluorspar, containing over 97% by weight of calcium fluoride		US$2.10 per ton		
522.24	Fluorspar, containing not over 97% calcium fluoride		13.5%		

Sources: Customs Tariff, 1987, Revenue Canada, Custom and Excise; Tariff Schedules of the United States Annotated (1987), USITC Publication 1910; U.S. Federal Register, Vol. 44, No. 241.

TABLE 1. CANADA, FLUORSPAR SHIPMENTS AND TRADE, 1984-87

	1984		1985		1986		1987	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Shipments								
Fluorspar	0	0	0	0	0	0	(1)	(1)
Imports							(Jan. - Sept.)	
Cryolite, Natural								
United States	117	94	64	39	1 156	805	1 045	720
Netherlands	152	75	218	102	251	123	445	192
Denmark	268	120	236	115	218	126	183	121
France	0	0	0	0	1 912	1 538	-	-
Total	537	288	518	257	3 537	2 592	1 673	1 033
Cryolite, Synthetic								
United States	14 292	9 003	8 230	6 688	3 492	2 681	2 882	2 332
Other countries	2 262	1 633	1 161	1 013	9 077	7 163	0	0
Total	16 554	10 636	9 391	7 701	12 569	9 844	2 882	2 332
Fluorspar								
Mexico	93 211	11 600	67 584	9 059	87 620	11 340	25 123	3 228
Morocco	33 610	4 505	18 277	2 679	33 089	4 484	11 500	1 670
China	0	0	0	0	4 882	507	9 272	1 311
Italy	0	0	0	0	0	0	7 805	976
United States	8 916	2 274	7 578	2 093	10 632	2 388	7 150	1 798
Spain	30 895	4 325	18 287	2 646	27 654	3 969	7 003	1 021
Nicaragua	67	13	0	0	0	0	-	-
France	0	0	0	0	234	71	-	-
Total	166 709	22 717	111 726	16 477	164 114	22 759	67 853	10 004
Hydrofluoric Acid								
United States	875	971	383	558	1 162	1 373	3 429	3 326
Japan	189	196	141	122	171	175	110	105
United Kingdom	3	3	86	96	220	224	52	52
West Germany	(2)	-	6	5	2	2	8	4
Total	1 067	1 170	616	780	1 555	1 774	3 609	3 487

Sources: Statistics Canada; Energy Mines and Resources Canada.
(1) Confidential; (2) Less than 1 tonne.
- Not reported.

TABLE 2. CANADA, FLUORSPAR REPORTED CONSUMPTION, 1984-86

Reported Consumption[1]	1984^r	1985	1986P
		(tonnes)	
Metallurgical flux	17 208	17 064	14 765
Foundries	6 496	6 945	6 222
Other[2]	153 148	127 082	126 153
Total	176 852	151 091	147 140

[1] Reported from EMR survey on the consumption of nonmetallic minerals by Canadian manufacturing plants. [2] Includes consumption in the production of aluminum, chemicals, ferro-alloys and other miscellaneous uses.
P Preliminary; ^{r} Revised.

TABLE 3. MAJOR CONSUMERS OF FLUORSPAR BY GRADE IN CANADA

Product	Major Consumers
Metallurgical grade (used as gravel or briquettes)	Stelco Inc. Ford Motor Company of Canada, Limited Sydney Steel Corporation Dofasco Inc. Atlas Steels division of Rio Algom Limited
Ceramic grade (used as powder)	The Algoma Steel Corporation, Limited Ferro Industrial Products Limited A.P. Green Refractories
Acid grade (used as powder or hydrofluoric acid)	Alcan Aluminium Limited Du Pont Canada Inc. General Chemical Canada Ltd. Timminco Limited

TABLE 4. WORLD ALL-GRADE FLUORSPAR PRODUCTION 1983-86

	1983	1984	1985P	1986^e
		(000 tonnes)		
Mexico	667	700	730	770
Mongolia	761	740	740	740
People's Republic of China	528	650	650	650
U.S.S.R.	595	550	560	560
South Africa	295	320	350	340
Spain	206	295	305	300
Thailand	227	290	300	255
France	264	230	230	235
United Kingdom	220	135	165	165
Italy	176	190	150	145
United States	61	65	60	70
Kenya	88	45	60	60
Other countries	612	575	570	580
Total	4 700	4 785	4 870	4 870

Source: U.S. Bureau of Mines, 1986 Fluorspar, L. Pelham.
^{e} Estimated; P Preliminary.

Gold

D. LAW-WEST

Gold prices increased in 1987, averaging US$447/oz. compared with $368 in 1986. The increase occurred in an orderly fashion, beginning the year just below the $400 mark and moving to just over $500 in December.

Canadian gold production increased to about 118 t from 103 t in 1986. By year-end, every province except Prince Edward Island had at least one primary gold mine, a change from the previous year when five provinces were without primary operations (several others recover by-product gold). Ten new gold mines began (or resumed) production in Canada in 1987, and at least fifteen others are scheduled to open in 1988 or 1989.

There was a significant change in the Canadian gold mining industry when Placer Development Limited, Dome Mines Limited and Campbell Red Lake Mines Limited amalgamated into Placer Dome Inc. The amalgamation resulted in the largest gold mining company in the western world outside of South Africa. Also of note was the formation of Hemlo Gold Mines Inc. through amalgamation of Noranda Hemlo Inc., Goliath Gold Mines Ltd. and Golden Sceptre Resources Ltd. interests in the Hemlo region. The company's major asset is the Golden Giant mine, at Hemlo.

ATLANTIC CANADA

In August, Hope Brook Gold Inc., a subsidiary of BP Resources Canada Limited, began heap leaching at its mine in southwestern Newfoundland. The project involves a 3 000 t/d leach and carbon-in-pulp mill plus open-pit and underground mines. Capital costs were expected to be just over $162 million. This includes about $14 million provided by the federal government's IRDP program, as well as $10 million provided by the provincial government for infrastructure. The mill and underground mine are scheduled for start-up in the latter half of 1988 at which time annual gold production will be 3 732 kg. The heap-leach operation treats open pit as well as some underground development ore and was expected to produce about 580 kg in 1987 and 1 775 kg in 1988, when it will be phased out.

In Nova Scotia, Seabright Resources Inc. reactivated the former Gays River base metal mill to treat gold ore from its nearby Forest Hill mine. The mill is rated at 440 t/d but consideration is being given to expanding this to 1 000 t/d. Seabright also owns several other promising gold deposits. The nearby Beaver Dam deposit, currently being developed underground, contains an estimated 1.5 Mt at 22.4 g/t. Late in 1987 Western Mining Corporation Limited offered to purchase all outstanding shares of Seabright for $92 million.

Gordex Minerals Limited plans to convert its Cape Spencer, N.B. heap-leach mine to vat-leaching to permit year-round operation.

QUEBEC

Gold production in Quebec increased slightly in 1987. In the Chibougamau region, Meston Lake Resources Inc. and Campbell Resources Inc. restarted the 700 t/d Joe Mann mine. An additional 910 000 t of ore grading 6.8 g/t were discovered below the old workings, sufficient for six years of production, but there is potential for additional discoveries. Campbell Resources also opened its S-3 mine, which has nearly three years of reserves. Production from the Joe Mann, S-3, Henderson No. 2 and Cedar Bay mines is treated at the 21 500 t/d Camchib mill.

In the Casa Berardi region, INCO Gold and Golden Knight Resources Inc. continued development of their Golden Pond joint venture. The Golden Pond East will be the first of three known deposits in the region to go into commercial production, in August 1988. The initial 800 t/d mill is designed for expansion to 2 000 t/d when the Golden Pond West deposit is placed into production. A $2 million surface drilling program is currently under way on the Golden Pond Main zone between the east and west zones.

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The initial 800 t/d stage will cost about $75 million, of which the Quebec government is providing $14.5 million for power lines and an access road.

Teck Corporation and Golden Hope Resources Inc. continued to evaluate the Estrades deposit some 30 km east of Casa Berardi. A $3.6 million surface drilling program established reserves of 2.3 Mt grading 4.4 g/t gold, 107 g/t silver, 0.8% copper, 7.39% zinc and 1.04% lead. The project is in the prefeasibility stage and a decision on an underground exploration program was being considered at year end.

The Val d'Or - Rouyn region remained quite active throughout the year. Lac Minerals Ltd. announced a $60 million development program for its Bousquet No. 2 mine, on the eastern boundary of the Bousquet No. 1 property. The company plans a 1 290 m shaft for production at 2 000 t/d beginning 1990. Expected gold production is 4 350 kg/y.

Lac Minerals and Cambior inc. are doubling capacity of the Doyon mill to 3 000 t/d at a cost of $17 million. An additional $21 million is being spent on underground development at the Doyon mine.

Dumagami Mines Limited, a subsidiary of Agnico-Eagle Mines Limited, continued construction near Lac Minerals' Bousquet No. 2 site. The 975 m shaft and a 2 000 t/d mill is scheduled to start-up in mid-1988. The operation is based on reserves of 2 Mt grading 5.75 g/t.

Perron Gold Mines Ltd., part of The Hughes-Lang Group, nearly completed construction by year-end at its Sleeping Giant property. Reserves outlined so far are 2 Mt grading 8.7 g/t. Production is scheduled for early 1988 at 1 000 t/d. Capital costs will total $45 million and gold output in 1988 is estimated at 1 890 kg. D'Or Val Mines Ltd., another member of The Hughes-Lang Group, began production at its Beacon mine in April.

ONTARIO

In Ontario, gold production received a boost as several new gold mines were commissioned during the year. Some established producers, including the three at Hemlo, also reported higher than expected production due to better ore grades and/or increased recoveries.

Lac Minerals announced plans for a $13 million, 1 250 t/d mill at Kirkland Lake to treat 500 t/d of ore from the Macassa mine and 750 t/d of tailings from Lake Shore. The mill is designed for a possible doubling of the tailings treatment capacity. The nearby Lake Shore mine was closed early in the year when recovery of the crown pillar was completed.

Emerald Lake Resources Inc. began production at its Golden Rose mine near Sturgeon Falls. The 400 t/d mill was moved from British Columbia. Reserves are 2.4 Mt at 7.29 g/t and gold production is expected to be 1 200 kg/y.

Canamax Resources Inc. and Pamorex Minerals Inc. brought the Bell Creek mine near Timmins into production during the last quarter. The 385 t/d mill will recover some 780 kg/y from reserves of nearly 1 Mt grading 5.75 g/t.

Placer Dome Inc. and Amoco Canada Petroleum Company Ltd. are nearing full production at the Detour Lake joint venture. Mining has switched from open pit to 1 800 t/d underground but the mill will operate at 2 200 t/d until 1991 when low grade stockpiled ore will be exhausted. Gold production is expected to exceed 3 000 kg in 1988.

Davidson Tisdale Mines Limited and Getty Resources Limited plan to develop the Tisdale property, near Timmins, with a 200 t/d mill, to recover 375 kg/y of gold.

Pamour Inc. and ERG Resources Inc. are proceeding with a $75 million tailings recycling operation in Timmins. Treatment of some 1.1 Mt/m of tailings will begin towards the end of 1988, with gold recovery expected to reach 2 500 kg/y.

MANITOBA

Granges Exploration Ltd. and Abermin Corporation began gold production at their Tartan Lake mine near Flin Flon. Expected gold production is 1 340 kg/y from the 500 t/d mill for at least seven years.

Pioneer Metals Corporation planned start-up of its Puffy Lake mine before the end of 1987. The 1 000 t/d mill is expected to produce 1 240 kg/y of gold.

SASKATCHEWAN

The province resumed primary gold production for the first time in fifty years when Saskatchewan Mining Development Corporation (SMDC) opened the Star Lake mine at the beginning of the year. Other partners in the 220 t/d operation are Uranerz Exploration and Mining Limited (15%) and Starrex Mining Corporation Ltd. (35%). The project will operate for about three years at 375 kg/y of gold.

The province's second gold producer will also likely be in the La Ronge region where several deposits are being considered for development, including the Jolu property of Mahogany Minerals Resources Inc. and the Seabee and Jojay properties of Claude Resources Inc.

BRITISH COLUMBIA

British Columbia gold production increased with the addition of one new producer.

Mascot Gold Mines Limited, now owned 51% by Lacana Mining Corporation, opened the Nickel Plate mine near Hedley in mid-year. The $70 million open pit mine-mill complex processes 2 500 t/d and is expected to produce at least 3 700 kg/y of gold.

In the Queen Charlotte Islands, City Resources (Canada) Limited is developing its Cinola gold deposit for production in 1989 at nearly 6 000 kg/y of gold.

North American Metals Corp. and Chevron Minerals Ltd. plan to develop the Golden Bear deposit near Dease Lake. Mineable reserves outlined to date are sufficient for at least six years at 360 t/d and an annual output of 2 000 kg of gold. The deposit will be mined simultaneously by open pit and underground methods. Capital costs are estimated at $36 million.

YUKON

While no new mines came into production in either of the Territories, production decisions were made for several new operations.

Canamax Resources Inc. and Pacific Trans-Ocean Resources Ltd. began construction at the Ketza River project near Ross River. The $20 million, 320 t/d operation will begin production by mid-1988. Reserves are estimated at about 1 600 kg/y of gold.

Omni Resources Inc. has discovered a high grade deposit at its property near Skukum Creek. Reserves are estimated at 600 000 t grading 11.5 g/t. Underground exploration is continuing.

NORTHWEST TERRITORIES

Giant Yellowknife Mines Limited, now the operating arm of Pamour Inc., closed its Salmita mine due to the depletion of ore reserves. The company is now re-treating tailings and expects to recover about 1 150 kg/y of gold. Underground development at the Giant mine is expected to increase gold production to 3 100 kg by 1990.

Treminco Resources Ltd. purchased the old Ptarmagin mine from Cominco Ltd. and expects to be recovering gold early in 1988. Ore reserves have been placed at 35 800 t containing some 1 550 kg of gold but there appears to be good potential for further reserves at depth. The company has recovered nearly 150 kg of gold from its nearby Tom property since late 1986. To date the ore has been custom milled at the Giant mill but Treminco is now considering a mill at the Tom mine to process ore from both its operations.

Noranda Exploration Company, Limited and Getty Resources Limited have outlined some 1.3 Mt grading 8.7 g/t at their Tundra property in the Courageous Lake area. A two-year, $25 million underground exploration program is now under way.

WORLD DEVELOPMENTS

Increased gold output is being reported by nearly every gold producing country in the world.

South Africa, the largest producer, is one of the few that have reported a drop in production to 605 t in 1987 from 638 t in 1986. This is the third consecutive year that the country's gold output has fallen. An important factor contributing to the fall in production was labour unrest by the black miners union during the year. In April, a number of short wildcat strikes briefly interrupted production at a few mines. However, in August a three week strike, which effectively shut down over half of the gold mines, cut production during the month by over 10 t.

United States gold production is expected to surpass 150 t in 1987, up nearly 35% from 112 t in 1986 and nearly double the output in 1985. New heap leaching operations in the western United States accounted for the major part of the additional output.

The Australian gold boom is expected to continue until at least the end of the decade when production should be well above 120 t, ten times the 1980 output of 12 t. Much of the new production is coming from Western Australia where exploration and development is proceeding at a high rate.

Papua New Guinea is also expected to increase its gold production substantially in the near future. While gold output from the Ok Tedi project will peak at 23 t, it will decline to about half that after the gold rich cap has been mined out late in 1988. Two other deposits, Porgera and Misima will eventually add substantial amounts of new gold to the country's output. The Porgera has a gold rich zone containing 4.5 Mt grading 21.9 g/t which could supply some 44.4 t/y for the first two years of production in the early 1990s. The Misima deposit, albeit smaller, will begin production in 1988 and could produce 7 t/y. In addition to these two well known deposits, PNG has excellent discovery potential for additional world class deposits.

Brazil is emerging as a major world gold producer. While official production showed a decrease in production from 72.3 t in 1985 to 67.4 t in 1986, 1987 production is expected to show a recovery to at least 80 t. Most of Brazil's production comes from small placer mines operated by garimpeiros and as a result large portions of production go unreported. Therefore, the numbers above are likely an understatement of the country's actual production. There has been an increase in activity by international mining companies in Brazil. RTZ Mineração Ltda and Antram Mineração e Participaceos S.A. poured the first gold at the new Morro do Ouro gold mine near Paracatu in Minas Gerais state. This open pit operation is expected to produce 3 000 kg/y of gold over its 15 year life.

Many other countries also reported increased gold production during the year, including Guyana, Ghana, Philippines and Indonesia.

CONSUMPTION AND USES

Information in this section is from the report Gold 1987, published by Consolidated Gold Fields PLC.

The use of gold in the manufacture of carat jewellery, coins and industrial purposes increased by almost 200 t to 1 666 t in 1986, with most of the increase occurring in the bullion coin sector.

As usual, the carat jewellery remained the largest consumer of gold, in spite of the marginal decrease to 1 097 t in 1986 compared to 1 126 t in the previous year. A major change occurred in the marketplace with the developed countries showing an increase in consumption reflecting general economic conditions, while developing countries registered a decline.

The electronic industry increased gold consumption by about 8% to 124 t, as it recovered from an oversupply of electronic components in 1985. Gold use in electronics is expected to decline as the result of miniaturization and substitution by other materials, a trend that will reduce unit use of gold, its recovery from such scrap will also be reduced.

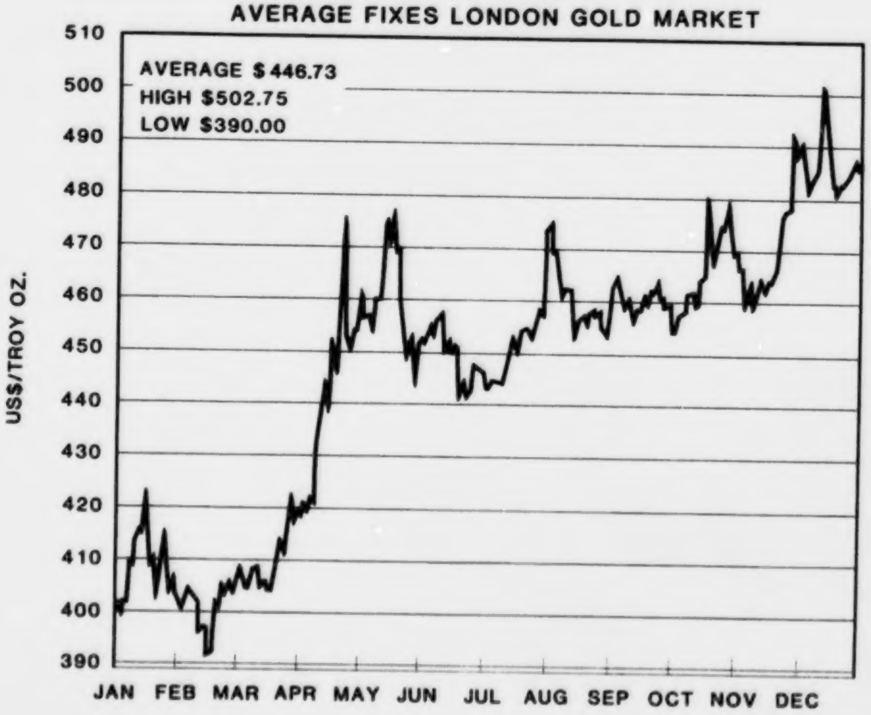
The use of gold in dentistry remained stable, at just over 50 t in 1986, but in the longer term it is expected to decline as alternative materials such as ceramics are improved. The general increase in dental hygiene also is reducing the actual need for gold applications, at least in the developed countries.

Official coins, including bullion coins, were the second largest user of gold in 1986 when over 315 t was consumed. The Japanese "Emperor" coin, commemorating the 60th anniversary of Emperor Hirohito, used 182 t and neared the record of 187 t, held by the South African Krugerrand, for the most coin sales in a single year. Both the United States and Australia reported very successful first year sales of their bullion coins. The Canadian Gold Maple Leaf has faced strong competition by these new coins and as a result will likely lose its market leader role.

OUTLOOK

Canadian gold production is expected to continue to rise through the early 1990s, and production could eventually surpass the record of 166 t set in the early 1940s. There is some concern that proposed changes to Canadian tax laws will curtail issues of flow-through shares and result in a significant drop in gold exploration which could adversely affect gold production later in the decade.

Gold prices in 1988 may be more volatile than in 1987, mainly as the result of increasing supplies from new low-cost mining operations throughout the world and especially in Australasia, United States, South America and Canada.



DAILY GOLD PRICES 1987
AVERAGE FIXES LONDON GOLD MARKET

TABLE 1. CANADA, GOLD PRODUCTION AND TRADE, 1985-87

	1985	1986	1987P
		(grams)	
Production			
Newfoundland	-	-	410 000
New Brunswick	283 445	373 658	442 200
Nova Scotia	-	-	155 500
Quebec	30 103 798	28 341 749	29 200 000
Ontario	32 261 375	46 278 552	54 069 500
Manitoba	2 162 285	2 555 506	3 752 800
Saskatchewan	224 743	13 872	945 800
Alberta	27 460	36 178	17 300
British Columbia	6 720 050	9 248 766	11 925 000
Yukon	3 064 763	3 547 359	5 105 900
Northwest Territories	12 712 939	12 503 280	11 810 300
Total	87 560 858	102 898 920	117 834 300
Total Value (C$)	1 219 653 297	1 689 291 569	2 242 858 463

	1985		1986		Jan.-Sept. 1987	
	(kilograms)	($000)	(kilograms)	($000)	(kilograms)	($000)
Imports						
Gold in ores and concentrates						
United States	284	3 657	344	4 960	68	749
Peru	108	1 310	168	2 228	182	2 799
Bolivia	5	55	6	84	7	112
Guyana	30	416	172	2 606	-	-
Other countries	48	662	20	254	116	2 085
Total	475	6 100	710	10 132	373	5 745
Gold						
United States	69 202	967 535	66 802	1 095 192	17 834	324 939
Switzerland	539	7 519	412	6 494	513	10 001
West Germany	377	5 293	100	1 596	14	243
Uruguay	-	-	276	4 696	4 425	80 993
Chile	44	621	-	-	319	5 981
Guyana	-	-	9	180	359	6 227
Other countries	1	26	4	88	565	10 941
Total	70 163	980 994	67 603	1 108 246	24 029	439 325

Gold alloys						
United States	17 441	211 415	44 779	612 510	17 193	277 407
Nicaragua	1 614	9 308	1 646	14 059	1 690	13 004
Mexico	22	288	-	-	111	2 129
Guyana	-	-	-	-	24	305
United Kingdom	78	63	57	103	34	60
West Germany	111	956	22	216	4	39
Other countries	6 452	72 069	1 013	18 890	2 041	32 276
Total	25 718	294 099	47 517	645 778	21 097	325 220
Exports						
Gold in ores and concentrates						
Japan	5 257	56 798	5 845	74 626	4 228	61 280
West Germany	-	1	211	3 768	659	1 102
Belgium-Luxembourg	65	837	116	1 862	390	6 225
People's Republic of China	-	-	396	4 716	120	1 667
Sweden	73	703	94	1 057	46	956
United Kingdom	45	502	78	933	43	619
United States	187	2 534	232	3 572	35	496
Other countries	407	3 844	216	2 833	725	19 743
Total	6 034	65 219	7 188	93 367	6 246	92 088
Gold						
United States	99 260	1 391 786	152 560	2 574 221	27 591	517 916
Japan	5 313	73 817	5 521	88 564	9 096	178 699
Switzerland	164	2 213	1 037	16 509	1 131	22 149
Italy	113	1 603	134	2 178	51	925
United Kingdom	6	73	46	818	53	924
Panama	1 754	24 755	553	8 629	41	753
Hong Kong	1 037	13 481	30	461	9	132
Other countries	10 290	141 468	7 634	122 177	10 632	208 468
Total	108 513	1 519 773	160 164	2 695 937	38 214	726 252
Gold alloys						
United States	1 962	22 574	4 222	55 097	259	2 813
Belgium-Luxembourg	-	-	-	-	7 181	118 809
Trinidad-Tobago	178	1 293	26	265	18	133
Italy	1	13	7	126	-	-
West Germany	2 561	31 458	1 038	14 226	-	-
Other countries	14	116	255	3 550	5	13
Total	4 716	55 454	5 548	73 264	7 563	121 768

Sources: Energy, Mines and Resources Canada; Statistics Canada.
P Preliminary; - Nil.

TABLE 2. CANADA, GOLD PRODUCTION BY SOURCE, 1970, 1975 AND 1980-87

	Auriferous Quartz Mines		Placer Operations		Base-Metal Ores		Total	
	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)
1970	58 592	78.2	229	0.3	16 095	21.5	74 915	100.0
1975	37 530	73.0	335	0.6	13 569	26.4	51 433	100.0
1980	31 929	63.1	2 060	4.0	16 632	32.9	50 620	100.0
1981	35 877	69.0	1 633	3.1	14 525	27.9	52 034	100.0
1982	47 866	74.0	2 477	3.8	14 393	22.2	64 735	100.0
1983	55 522	75.5	3 235	4.4	14 756	20.1	73 512	100.0
1984	62 554	75.0	3 393	4.1	17 499	20.9	83 446	100.0
1985	67 241	76.8	3 464	4.0	16 857	19.2	87 561	100.0
1986[e]	83 197	80.9	2 802	2.7	16 900	16.4	102 899	100.0
1987[P]	97 096	82.4	3 659	3.1	17 086	14.5	117 834	100.0

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[e] Estimated; [P] Preliminary.

TABLE 3. CANADA, GOLD PRODUCTION AND AVERAGE VALUE

	Total Production	Total Value	Average Value[1]
	(kg)	(000 C$)	(C$/g)
1970	74 915	88 057	1.18
1975	51 433	270 830	5.27
1980	50 620	1 165 416	23.02
1981	52 034	922 089	17.72
1982	64 735	968 012	14.95
1983	73 512	1 230 886	16.74
1984	83 446	1 252 283	15.01
1985	87 561	1 219 653	13.93
1986[e]	102 899	1 689 292	16.39
1987[P]	117 834	2 242 858	19.03

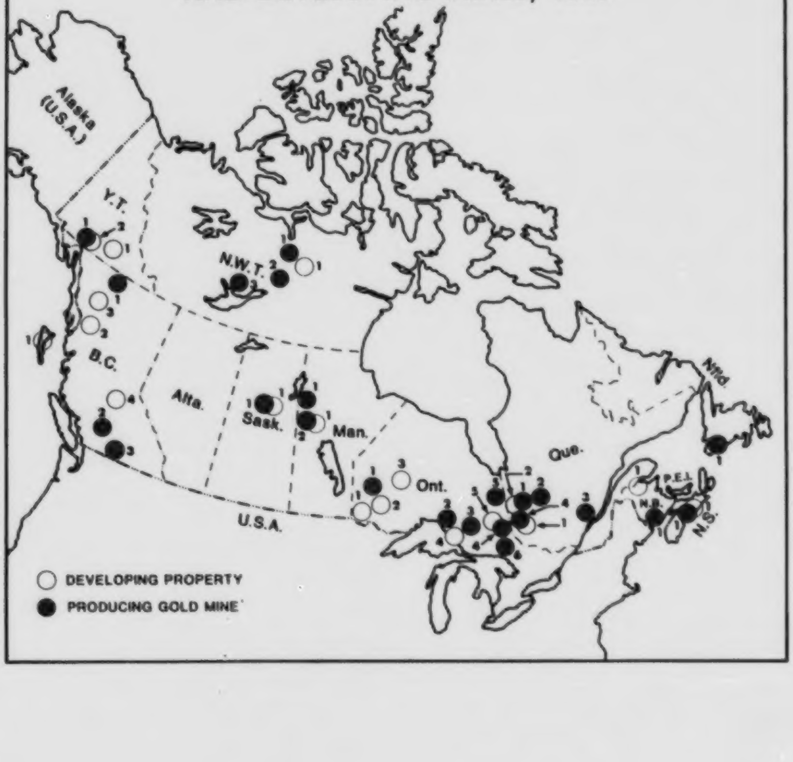
Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Value is based on average reported sales.
[e] Estimate; [P] Preliminary.

TABLE 4. GOLD MINE PRODUCTION IN THE NON-COMMUNIST WORLD

	1980	1981	1982	1983	1984	1985	1986
				(tonnes)			
South Africa	675.1	657.6	664.3	679.7	683.3	673.3	640.0
Canada	50.6	52.0	64.7	73.5	83.4	87.5	102.9
United States	30.2	42.9	45.0	60.9	68.5	79.0	108.0
Other Africa:							
Ghana	10.8	11.6	12.0	11.8	11.6	12.0	11.5
Zimbabwe	11.4	11.6	13.4	14.1	14.5	14.7	14.9
Zaire	3.0	3.2	4.2	6.0	10.0	8.0	8.0
Other	8.0	12.0	15.0	15.0	15.0	17.0	18.2
Total Other Africa	33.2	38.4	44.6	46.9	51.1	51.7	52.6
Latin America:							
Brazil	35.0	35.0	34.8	58.7	55.1	63.3	67.4
Bolivia	2.0	2.5	2.5	3.0	4.0	6.0	6.0
Colombia	17.0	17.7	15.5	17.7	21.2	26.4	27.1
Dominican Republic	11.5	12.8	11.8	10.8	10.6	10.4	9.1
Chile	6.5	12.2	18.9	19.0	18.0	18.2	19.2
Peru	5.0	7.2	6.9	9.9	10.5	10.9	10.9
Mexico	5.9	5.0	5.2	7.4	7.5	8.0	8.3
Venezuela	1.0	1.5	2.0	6.0	9.5	12.0	15.0
Other	4.8	6.0	6.7	8.6	5.5	8.0	7.5
Total Latin America	88.7	99.9	104.3	141.1	148.3	172.2	170.5
Asia:							
Philippines	22.0	24.9	31.0	33.3	34.3	37.2	39.9
Japan	6.7	5.8	5.6	5.9	7.0	9.0	14.0
India	2.6	2.6	2.2	2.2	2.0	1.7	2.1
Other	4.5	4.6	5.2	5.3	7.4	9.6	14.6
Total Asia	35.8	37.9	44.0	46.7	50.7	57.5	70.6
Europe	11.8	11.9	12.4	14.1	15.1	16.5	16.5
Oceania:							
Papua/New Guinea	14.3	17.2	17.8	18.4	18.7	31.3	36.1
Australia	17.0	18.4	27.0	30.6	39.1	58.5	75.0
Other	1.0	1.1	1.2	1.8	1.8	2.8	4.0
Total Oceania	32.3	36.7	46.0	50.8	59.6	92.6	115.1
TOTAL	957.7	977.3	1 025.3	1 113.7	1 160.0	1 230.3	1 276.2

Source: Consolidated Gold Fields PLC, Gold 1987, p. 18.

PRINCIPAL CANADIAN GOLD PRODUCERS AND DEVELOPING MINES, 1987


Alaska (U.S.A.)
Y.T.
N.W.T.
B.C.
Alta.
Sask.
Man.
Ont.
Que.
Nfld.
P.E.I.
N.B.
N.S.
U.S.A.
○ DEVELOPING PROPERTY
● PRODUCING GOLD MINE

MAJOR PRIMARY CANADIAN GOLD PRODUCERS, 1987

Yukon Territories:

1. Total Erickson Resources Ltd. - Mt. Skukum mine

Northwest Territories:

1. Echo Bay Mines Ltd. - Lupin mine
2. Giant Yellowknife Mines Limited - Salmita mine
3. Giant Yellowknife Mines Limited - Giant mine
   NERCO Minerals Company - Con mine

British Columbia:

1. Total Erickson Resources Ltd. - Cassiar
2. Kerr Addison Mines Limited/Blackdome Mining Corporation - Blackdome mine
3. Mascot Gold Mines Limited - Nickel Plate mine

Saskatchewan:

1. Saskatchewan Mining Development Corporation/Starre Mining Corporation Limited/Uranerz Exploration and Mining Limited - Star Lake mine

Manitoba:

1. SherrGold Inc. - MacLellan mine
2. Gränges Exploration Ltd./Abermin Corporation - Tartan Lake mine

Ontario:

1. Red Lake Area
   - Placer Dome Inc.
   - Dickenson-Sullivan Joint Venture
2. Hemlo Area
   - Lac Minerals Ltd. - Page-Williams mine
   - Hemlo Gold Mines Inc. - Golden Giant mine
   - Teck-Corona Operating Corporation - David Bell mine
3. American Barrick Resources Corporation/Royex Gold Mining Corporation - Renabie mine
4. Timmins - Kirkland Lake Area
   - Placer Dome Inc. - Dome mine
   - Pamour Inc. (Jimberlana Minerals NL) - Pamour #1, Timmins and Ross mines
   - Kidd Creek Mines Ltd. (Falconbridge) - Owl Creek, Hoyle Pond
   - Lac Minerals Ltd. - Macassa, Lake Shore mine
   - Kerr Addison Mines Limited - Kerr Addison mine
   - INCO Limited/Queenston Gold Mines Limited Joint Venture - McBean mine
   - Canamax Resources Inc./Pamorex Minerals Inc. - Bell Creek mine
5. Placer Dome Inc./Amoco Canada Petroleum Company Ltd. Joint Venture - Detour Lake mine
6. Sudbury-North Bay Area
   - Emerald Lake Resources Inc. - Golden Rose mine
   - Orofino Resources Limited - Norstar mine

Quebec:

1. Agnico-Eagle Mines Limited - Telbel mine
2. Bachelor Lake Gold Mines Inc.
   Minnova Inc. - Lac Shortt mine
   Campbell Resources Inc. - Joe Mann mine
3. Muscocho Explorations Ltd. - Montauban mine
4. Noranda/Rouyn - Val d'Or Area
   - Lac Minerals Ltd. - Doyon mine/Bousquet mine
   - American Barrick Resources Corporation - Camflo
   - Belmoral Mines Ltd. - Belmoral mine
   - Kiena Gold Mines Limited - Kiena mine
   - Sigma Mines (Quebec) Limited - Sigma mine
   - Louvem Mines Inc. - Chimo mine
   - D'Or Val Mines Ltd. - Beacon mine
   - Audrey Resources Inc. - Mobrun mine
   - Belmoral Mines Ltd. - Ferderber mine, Dumont mine

New Brunswick:

1. Gordex Minerals Limited - Cape Spencer mine

Nova Scotia:

1. Seabright Resources Inc. - Forest Hill and Beaver Dame mines

Newfoundland:

1. Hope Brook Gold Inc. - Hope Brook mine

DEVELOPING PROPERTIES IN CANADA, 1987

Yukon Territories

1. Canamax Resources Inc./Pacific Trans-Ocean Resources Ltd.
   Ketza River Property
2. Omni Resources Inc. - Skukum Creek

Northwest Territories

1. Noranda Exploration Company, Limited/Getty Resources Limited - Courageous Lake

British Columbia

1. City Resources (Canada) Limited - Cinola Property
2. North American Metals Corp./Chevron Minerals Ltd. - Golden Bear Property
3. Skyline Explorations Ltd. - Reg Property
4. Cheni Gold Mines Inc. - Lawyers Project

Saskatchewan

1. La Ronge Area
    - Mahogany Minerals Resources Inc. Jolu Project
    - Placer Dome Inc./Claude Resources Inc. - Seabee Project, Jojay Project

Manitoba

1. Hudson Bay Mining and Smelting Co., Limited/Outokumpu Oy/Gränges Exploration Ltd. - Trout Lake
   Pioneer Metals Corporation - Puffy Lake Project

Ontario

1. Consolidated Professor Mines Limited - Duport
2. Echo Bay Mines Ltd./Nuinsco Resources Limited - Cameron Lake
3. Placer Dome Inc. - Dona Lake
   St. Joe Minerals Corporation - Golden Patricia
4. MacMillan Energy Corp., Gränges Exploration Ltd. - Mishibishu Lake
   Canamax Resources Inc./Kremzar Gold Mines, Limited - Kremzar
5. Timmins - Kirkland Lake Area
    - Getty Mines, Limited/Davidson Tisdale Mines Limited - Davidson Tisdale mine
    - Diepdaume Mines Limited - Diepdaume mine
    - Canamax Resources Inc./Bruneau Mining Corporation - Clavos Project
    - St. Andrew Goldfields Ltd. - St. Andrews mine
    - American Barrick Resources Corporation - Holt-McDermott

Quebec

1. Noranda/Rouyn - Val d'Or Area
    - Dumagami Mines Limited - East and West Zones
    - Belmoral Mines Ltd. - Bourlamaque mine
    - Louvem Mines Inc. - North Pascalis
    - Lac Minerals Ltd. - Bousquet No. 2 mine
2. Casa Berardi Area
    - INCO Limited/Golden Knight Resources Inc. - Golden Pond Project
    - Teck Corporation/Golden Hope Resources Inc. - Estrades Project

New Brunswick:

1. Northumberland Mines Limited - Murray Brook Property

Nova Scotia:

1. Coxheath Gold Holdings Limited - Tangiers Property
   Northumberland Mines Limited/INCO Gold - Cochrane Hill Property

Gypsum and Anhydrite

O. VAGT

SUMMARY 1987

The strong demand for gypsum wallboard by the building construction industry in the United States continued through 1987. In support of this demand, exports of crude gypsum particularly from Atlantic Canada, along with production (shipments), continued at about 1985-86 levels. Total Canadian shipments were 8.8 Mt in 1987, according to preliminary figures. Exports of gypsum wallboard to the United States reached record amounts in 1986 at more than 76 million square metres but fell in 1987 partly as a result of a drop in U.S. housing starts during the third quarter. Canadian demand for wallboard increased substantially during the year mainly as a result of strong residential construction in Ontario and Quebec. Housing starts in 1987 were about 245 000, up from 200 000 in 1986, according to preliminary figures. Imports of gypsum wallboard were up considerably and spot shortages along with price increases occurred.

Canadian production of crude gypsum is mainly from Atlantic Canada where major deposits, principally in Nova Scotia and Newfoundland, have been worked for many years. Most operations are Canadian subsidiaries of United States gypsum products producers. The region accounts for over 75% of Canadian gypsum production and for the major portion of exports. Shipments are made from quarries in the Atlantic region to wallboard plants and portland cement plants in Quebec and Ontario. New Brunswick production is used locally by a cement producer. Ontario production is used on-site except in the case of Westroc Industries Limited at Drumbo which ships to its Mississauga wallboard plant. Production from Manitoba and from Windermere, Canal Flats (Lussier River) and Falkland in British Columbia supply the Prairie Region and most of the British Columbia markets. Imports from Mexico and the United States are used by both wallboard and cement producers in British Columbia.

CANADIAN DEVELOPMENTS

Gypsum production in Canada is in direct response to demand from the wallboard industries in Canada and the United States, which in turn satisfies demand from the building construction sector for residential, institutional and commercial construction projects. Fire retardant qualities of gypsum wallboard have encouraged its greater application for non-residential uses in recent years. This trend, along with increased amounts being used in renovation of older buildings, has made housing starts a less-than-accurate indicator of wallboard demand.

The portland cement industry uses up to 5% by weight of gypsum intimately ground with cement clinker to act as a set inhibitor. This could amount to more than 500 000 t/y in Canada.

Negotiations by Domtar Inc. relating to the acquisition of Genstar Gypsum Limited's wallboard plants in Edmonton and Saskatoon, along with four board plants in the United States and a gypsum quarry operated seasonally in Newfoundland, were finalized in February 1987. The Newfoundland quarry at Flat Bay and marine terminal at nearby St. Georges closed at year-end. Domtar, in cooperation with the Government of Newfoundland, is pursuing all opportunities to find a buyer with a view to maintaining activity. In Ontario, Domtar is developing a new underground mine to supply its adjacent gypsum board complex at Caledonia, Ontario. This facility supplies 70 Mm^2/y of wallboard to construction and renovation markets in the United States and Canada. Development costs are estimated at $13 million and full production is planned for 1990 when existing reserves are exhausted. New reserves at present levels of output are expected to be sufficient for 75 years.

CGC Inc., now a public company owned 75% by USG Corporation of Chicago, diversified further into manufactured products and installation. CGC plans an

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expansion and modernization project at its Montreal wallboard plant.

Because gypsum is a relatively low-cost, high-bulk mineral commodity it is generally produced from deposits situated as conveniently as possible to areas in which markets for gypsum products exist. Exceptions occur if deposits of unusually high quality are available, even at some distance from markets, if comparatively easy and inexpensive mining methods are applicable, or if low-cost, high-bulk shipping facilities are accessible. Nova Scotia and Newfoundland deposits meet all three of these criteria and have been operated for many years by, and for, United States companies in preference to some known but unexploited United States deposits. Imports of gypsum to Canada and the United States from Mexico have been made possible because these criteria have been met and recently, with strong demand, good prices, low production costs and competitive shipping arrangements, gypsum from Spain has been back-hauled to United States ports.

In Canada, occurrences besides those currently being exploited are known in the southwest lowlands, west of the Long Range Mountains in Newfoundland; throughout the central and northern mainland of Nova Scotia as well as on Cape Breton Island; in the southeastern counties of New Brunswick; on the Magdalen Islands of Quebec; in the Moose River, James Bay and southwestern regions of Ontario; in Wood Buffalo National Park, in Jasper National Park, along the Peace River between Peace Point and Little Rapids, and north of Fort Fitzgerald in Alberta; on Featherstonhaugh Creek, near Mayook, at Canal Flats, and Loos in British Columbia; on the shores of Great Slave Lake, the Mackenzie, Great Bear and Slave rivers in the Northwest Territories; and on several Arctic islands.

WORLD DEVELOPMENTS AND TRADE

Gypsum occurs in relative abundance throughout the world, however with dependence on the building construction industry, developments are generally limited to the industrialized countries. Reserves are extremely large and are conservatively estimated at over 2 billion t. Canada is the world's second largest producer of natural gypsum after the United States together accounting for about 25% of world output.

Gypsum products, particularly wallboard, have limited market range because of high unit weight, friability, high transportation costs and relatively low unit values. These factors generally dictate that markets are supplied from the closest producer. There are exceptions, however, and gypsum wallboard has been shipped not only between the United States and Canada over surprisingly great distances but shiploads of wallboard have been received at United States southeast ports from European producers. The Canada-United States trade is usually in truckload lots of 20 to 25 t for delivery to warehousing or to job sites. However, with recent strong demand requiring shipments beyond the economic limits of trucking facilities, shipments by rail have become common.

USES

Gypsum is a hydrous calcium sulphate ($CaSO_4.2H_2O$) which, when calcined at temperatures ranging from 120° to 205°C, releases three-quarters of its chemically combined water. The resulting hemihydrate of calcium sulphate, commonly referred to as plaster of paris, when mixed with water, can be moulded, shaped or spread and subsequently dried, or set, to form a hard plaster product. Gypsum is the main mineral constituent in gypsum wallboard, lath and tile. Anhydrite, an anhydrous calcium sulphate ($CaSO_4$), is commonly associated geologically with gypsum.

Crude gypsum is crushed, pulverized and calcined to form stucco, which is mixed with water and aggregate (sand, vermiculite or expanded perlite) and applied over wood, metal or gypsum lath to form interior wall finishes. Gypsum board, lath and sheathing are formed by introducing a slurry of stucco, water, foam, pulp and starch between two unwinding rolls of absorbent paper; the result is a continuous "sandwich" of wet board. As the stucco hardens, the board is cut to predetermined lengths, dried, bundled and stacked for shipment.

Grinding, calcining and drying are the main energy-using steps in the manufacture of gypsum wallboard. In the interests of energy conservation and process cost reduction in general, significant savings have been achieved by recycling heat from calcining kettles for use in preheating and in board drying. One-step grinding and calcining as an alternative to either the batch kettle or the continuous kettle has been adopted by one producer. There is also a trend towards using less calcined gypsum in board while using greater amounts of foam and more effective dispersing agents to obtain a lighter-weight unit with equal or greater strength.

Keene's cement is made by converting crushed gypsum to insoluble anhydrite by calcining at temperatures as high as 700°C, usually in rotary kilns. The ground calcine, mixed with a set accelerator, produces a harder and stronger plaster product than ordinary gypsum plaster.

Crude gypsum is also used in the manufacture of portland cement where it acts as a retarder to control set. It is used as a filler in paint and paper manufacture, as a substitute for salt cake in glass manufacture and as a soil conditioner.

By-product gypsum, produced from the acidulation of phosphate rock in phosphate fertilizer manufacture, has not been utilized in Canada despite available technology from European countries and from Japan. In these countries, by-product gypsum is used in the manufacture of gypsum products, by cement manufacturing plants, and also for soil stabilization. Recent experiments in France have produced paper with a 20% phosphogypsum content as filler. Studies have indicated that a potential radiation hazard exists in the use of phosphogypsum produced from sedimentary phosphate rock which can contain significant quantities of uranium and radium. Fluorogypsum is a by-product of the manufacture of hydrofluoric acid. Cooperative research programs have been conducted to determine the suitability of using waste fluorogypsum from Allied Chemicals Canada Inc., Amherstburg, Ontario plant at St. Lawrence Cement Inc.'s Clarkson, Ontario cement plant.

The use of lime or limestone to desulphurize stack gases from utility or industrial plants burning high-sulphur fuel will also result in the production of large amounts of waste gypsum in the form of a sludge which will present disposal problems if profitable uses are not developed.

Canadian Standards Association (CSA) Standards A 82.20 and A 82.35 relate to gypsum and gypsum products.

OUTLOOK

Canada's economic recovery picked up considerably with an annual growth rate of about 6% during the first half of the year and 4% during the third quarter of 1987. Until this year however, recovery lagged uncommonly far behind recovery in the United States since 1982. The construction industry in the United States became very active following the 1980-81 recession and demand for the materials of construction presented opportunities for Canadian producer-exporters of cement, clinker, gypsum and gypsum wallboard. Canadian business investment remained low and construction expenditures, particularly in engineering projects actually decreased. Indicators including relatively low interest rates, falling unemployment and moderate consumer prices suggest a positive outlook for the building construction sector. However, housing starts in 1988 are expected to decline substantially in Ontario and Quebec. The Alberta economy is making a significant recovery from a decline in oil and gas-investment that took place in 1986. This is expected to help broaden the construction activity in the western region.

The Canadian Construction Association is predicting increases in the non-residential contract construction industry constant dollar expenditures of 4.5% from 1986 to 1995. The construction industry as a whole has expressed concern that Canada's large infrastructure network needs attention, leading to major renovation and upkeep projects similar to those begun on the United States highway system. Such a program would permit the construction industry and that portion of the mining industry which depends on it to plan five to ten years ahead with obvious benefits in efficiency, rather than to invest with short-term survival as the main incentive. The need for gypsum-based building products is expected to continue rising in the building construction sector. Although new construction materials are being introduced, gypsum wallboard will remain popular because of its low price, ease of installation and well-recognized insulating and fire-retarding properties. The present structure of the gypsum industry in Canada is unlikely to change greatly in the near future. Building materials plants have sufficient capacities to meet the short-term, regional demand for products and to supply at least some of the unusually high demand from the United States.

ANHYDRITE

Production and trade statistics for anhydrite are included with gypsum statistics. Anhydrite is produced by Fundy Gypsum Company Limited at Wentworth, Nova Scotia, and by Little Narrows Gypsum Company Limited at Little Narrows, Nova Scotia.

According to the Nova Scotia Department of Mines and Energy, production of anhydrite in 1985 was 199 813 t and in 1986 was 153 724 t. Most of this was shipped to the United States for use in portland cement manufacture and as a peanut crop fertilizer. Cement plants in Quebec and Ontario also used some Nova Scotia anhydrite.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
CANADA					
29200-1	Gypsum, crude	free	free	free	free
29300-1	Plaster of paris, or gypsum, calcined, and prepared wall plaster, weight of package to be included in weight for duty; per hundred pounds	free	4.0¢	12.5¢	free
29400-1	Gypsum, ground, not calcined	free	free	15	free
28410-1	Gypsum tile	9.2	9.2	25	6.0
19200-7	Gypsum wallboard	9.4	9.4	35	free
UNITED STATES (MFN)					
512.21	Gypsum crude		free		
512.24	Gypsum, ground calcined, per ton		42¢		
245.70	Gypsum or plaster building boards and lath, ad valorem		2.4%		

Sources: The Customs Tariff, 1987, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1987), USITC Publication 1910; U.S. Federal Register, Vol. 44, No. 241.

TABLE 1. CANADA, GYPSUM PRODUCTION AND TRADE, 1985-87

	1985		1986		1987^P	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Production (shipments)						
Crude gypsum						
Nova Scotia	5 479 275^r	43 357^r	6 263 988	50 126	6 034 477	51 010
Ontario	1 114 437	15 056	1 321 457	16 974	1 439 303	18 736
British Columbia	453 833	4 659	485 279	4 896	496 900	5 304
Newfoundland	517 621	6 096	485 576	6 038	410 195	4 656
Manitoba	195 623	1 997	246 505	5 039	430 661	8 202
Total[1]	7 760 783^r	71 164^r	8 802 805	83 073	8 811 536	87 908
Imports						
					(Jan.-Sept.)	
Crude gypsum						
Spain	10 839	362	87 393	705	83 327	735
Mexico	92 769	3 022	101 376	3 268	90 423	2 804
United States	18 103	552	32 775	649	10 835	278
Hong Kong	91	3	100	3	161	3
Total	121 802	3 939	221 644	4 625	184 746	3 820
Plaster of paris and wall plaster						
United States	24 622	5 833	21 294	5 154	18 138	3 727
France	-	-	-	-	-	-
United Kingdom	-	-	-	-	-	-
Italy	-	-	-	-	-	-
Other countries	8	2	13	3	2	1
Total	24 630	5 835	21 307	5 157	18 140	3 728
	(square metres)		(square metres)		(square metres)	
Gypsum lath, wall-board and basic products						
United States	1 873 879	2 727	1 696 814	2 902	4 068 468	7 162
Other countries	44 846	87	94 206	154	69 830	98
Total	1 918 725	2 814	1 791 020	3 056	4 138 298	7 260
Total imports gypsum and gypsum products		12 588		12 838		14 808
	(tonnes)		(tonnes)		(tonnes)	
Exports						
Crude gypsum						
United States	5 844 706	49 599	5 885 295	51 534	4 327 746	37 601
Other countries	35 728	266	21	3	183	84
Total	5 879 664^r	49 865	5 921 982^r	51 537	4 327 929	37 685
	(square metres)		(square metres)		(square metres)	
Gypsum lath, wallboard and basic products						
United States	69 520 421	115 512	76 523 724	134 938	51 177 897	82 431
Saudi Arabia	44 592	121	-	-	-	-
Algeria	51 971	68	29 438	71	15 655	28
Bermuda	62 587	87	61 837	102	21 414	44
Other countries	290 569	641	75 037	144	28 796	73
Total	69 970 140	116 429	76 690 036	135 255	51 243 762	82 576
Total exports of gypsum and gypsum products		166 294		186 792		120 261

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Totals do not include gypsum produced by or shipped for use by Canadian portland cement producers.

^{P} Preliminary; - Nil; ^{r} Revised.

Note: Totals may not add due to rounding.

TABLE 2. CANADA, GYPSUM MINING AND GYPSUM PRODUCTS MANUFACTURING OPERATIONS, 1987

Company	Location	Operation
Newfoundland		
Domtar Inc.[1]	Flat Bay	Open-pit mining - closed December, 1987
Atlantic Gypsum Limited	Corner Brook	Wallboard manufacture
Nova Scotia		
Domtar Inc.	M^c^Kay Settlement	Open-pit mining of gypsum by contract
	Windsor	Plaster and "Gypcrete" manufacture
Fundy Gypsum Company Limited	Wentworth and Miller Creek	Open-pit mining of gypsum and anhydrite
Georgia-Pacific Corporation	River Denys	Open-pit mining of gypsum
Little Narrows Gypsum Company Limited	Little Narrows	Open-pit mining of gypsum and anhydrite
National Gypsum (Canada) Ltd.	Milford	Open-pit mining of gypsum
New Brunswick		
Canada Cement Lafarge Ltd.	Havelock	Open-pit mining of gypsum for cement manufacture
Quebec		
CGC Inc.	Montreal	Wallboard manufacture
	St-Jerome	Wallboard manufacture - closed mid-1982, reopened early 1984
Domtar Inc.	Montreal	Wallboard plant now used only as distribution terminal
Westroc Industries Limited	Ste. Catherine d'Alexandrie	Wallboard manufacture
Ontario		
CGC Inc.	Hagersville	Underground mining and wallboard manufacture
Domtar Inc.	Caledonia	Underground mining and wallboard manufacture
Westroc Industries Limited	Drumbo	Underground mining
	Clarkson	Wallboard manufacture
Manitoba		
Domtar Inc.	Gypsumville	Open-pit mining
	Winnipeg	Wallboard manufacture
Westroc Industries Limited	Amaranth	Open-pit mining
	Winnipeg	Wallboard manufacture
Saskatchewan		
Domtar Inc.	Saskatoon[1]	Wallboard manufacture
Alberta		
Domtar Inc.	Calgary	Wallboard and "Gypcrete" manufacture
	Edmonton[1]	Wallboard manufacture
Westroc Industries Limited	Calgary	Wallboard manufacture
British Columbia		
Domtar Inc.	Canal Flats	Open-pit mining
	Vancouver	Gypsum products manufacture
Westroc Industries Limited	Vancouver[2]	Gypsum products manufacture
	Windermere	Open-pit mining
	Vancouver[3]	Gypsum products manufacture

[1] Genstar affiliated operation acquired by Domtar Inc. in June 1985. [2] Genstar plant in Vancouver acquired by Westroc Industries Limited in June 1985. [3] Westroc Industries Limited Vancouver plant closed in June 1985.

TABLE 3. CANADA, GYPSUM PRODUCTION, TRADE AND CONSUMPTION, 1975, 1979-86

	Production[1]	Imports[2]	Exports	Apparent Consumption[3]
		(tonnes)		
1975	5 719 451	55 338	3 691 676	2 083 113
1979	8 098 166	152 953	5 474 765	2 776 354
1980	7 336 000	154 717	4 960 240	2 530 477
1981	7 025 000	143 500	5 094 873	2 073 627
1982	5 987 000	93 843	4 775 755	1 305 088
1983	7 507 000	100 939	5 187 032	2 420 907
1984	7 775 082	131 809	6 224 574	1 682 317
1985	7 760 783^r	121 802	5 879 664^r	2 002 921^r
1986	8 802 805	221 644	5 921 982^r	3 102 467^r

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Producers' shipments, crude gypsum. [2] Includes crude and ground, but not calcined.
^{r} Revised.

TABLE 4. CANADA, HOUSE CONSTRUCTION, BY PROVINCE, 1985 AND 1986

	Starts			Completions			Under Construction		
	1985	1986	% Diff.	1985	1986	% Diff.	1985	1986	% Diff.
Newfoundland	2 854	2 883	1.0	1 852	2 400	29.6	3 348	3 823	14.2
Prince Edward Island	788	1 110	40.9	757	1 176	55.4	420	362	-13.8
Nova Scotia	6 923	7 571	9.4	5 748	7 571	31.7	3 474	3 435	-1.1
New Brunswick	4 142	4 045	-2.3	3 224	4 504	39.7	2 137	1 770	-17.2
Total (Atlantic Provinces)	14 707	15 609	6.1	11 581	15 651	35.1	9 379	9 390	0.1
Quebec	48 031	60 348	25.6	41 577	56 984	37.1	21 270	24 531	15.3
Ontario	64 871	81 470	25.6	50 590	69 567	37.5	36 761	48 625	32.3
Manitoba	6 557	7 699	17.4	5 081	7 341	44.5	3 817	4 178	9.5
Saskatchewan	5 354	5 510	2.9	5 653	5 072	-10.3	2 866	3 255	13.6
Alberta	8 337	8 462	1.5	7 517	9 172	22.0	3 518	2 913	-17.2
Total (Prairie Provinces)	20 248	21 671	7.0	18 251	21 585	18.3	10 201	10 346	1.4
British Columbia	17 969	20 687	15.1	17 107	20 818	21.7	8 755	8 548	-2.4
Total Canada	165 826	199 785	20.5	139 106	184 605	32.7	86 366	101 440	17.5

Source: Canada Mortgage and Housing Corporation.

TABLE 5. CANADA, VALUE OF CONSTRUCTION[1] BY TYPE, 1985-87

	1985	1986	1987
		($ millions)	
Building Construction			
Residential	24 145	28 637	29 281
Industrial	3 470	3 129	2 996
Commercial	8 697	9 865	10 744
Institutional	3 119	3 488	3 697
Other building	2 028	1 883	1 972
Total	41 459	47 002	48 690
Engineering Construction			
Marine	379	387	473
Highways, airport runways	5 179	5 029	5 216
Waterworks, sewage systems	2 481	2 258	2 488
Dams, irrigation	283	272	273
Electric power	3 314	3 649	3 964
Railway, telephones	2 787	2 627	2 903
Gas and oil facilities	9 207	6 638	5 683
Other engineering	2 894	2 544	2 658
Total	26 524	23 404	23 658
Total construction	67 983	70 406	72 348

Source: Statistics Canada.

[1] Actual expenditures 1985, preliminary actual 1986, intentions 1987.

TABLE 6. WORLD PRODUCTION OF GYPSUM, 1985 AND 1986

	1985	1986^e
	(000 tonnes)	
United States	13 359	14 787
Canada	8 447	8 803
Japan	6 260	6 169
France	5 443	5 534
Spain	5 262	5 443
People's Republic of China	4 990	4 990
U.S.S.R.	4 899	4 899
Iran	4 989	4 808
United Kingdom	3 074	3 084
Mexico	2 812	3 175
West Germany	1 996	2 268
Other market economy countries	14 709	15 150
Other central economy countries	4 682	4 717
World total	80 922	83 827

Sources: Energy, Mines and Resources Canada; U.S. Bureau of Mines Mineral Commodity Summaries, January 1986.

^{e} Estimated.

Iron Ore

B.BOYD AND T.R. McINNIS

There were indications that world production, consumption and trade in iron ore improved slightly in 1987. Total world production was 914.7 Mt in 1986. New projects and expansions were brought onstream in several countries while the industry stabilized in North America. The market for iron ore pellets tightened toward year-end while the lump ore and fines markets remained soft. Although the steel industries in North America and western Europe began to stabilize, trade patterns for iron ore continued to shift because the Japanese steel industry underwent a major restructuring.

The world price of iron ore fell slightly in 1987, as it had each year since 1982. A further problem for Canadian producers was a trend to sell a larger proportion of their production each year at the world price. The effect in 1987 was an average revenue of $33.40 per tonne, the lowest since 1980, and a decrease of about $4/t from last year.

The Canadian iron ore industry was relatively stable in a changing market. Productivity increased due to many improvements, and cost control had priority at all operations. The mines in the Quebec-Labrador region intensified their marketing efforts offshore, successfully signing new contracts. Strikes at two major mines resulted in the closure of their operations for one and two months, respectively.

CANADIAN DEVELOPMENTS

Canadian shipments of iron ore increased 1.4 Mt relative to 1986 and, at 37.5 Mt, had a value of $1254 million. Production was estimated at 36.9 Mt, representing 74% of capacity.

Two of Canada's three large iron ore operations went on strike during March after contracts expired on February 28, 1987. The Iron Ore Company of Canada (IOC) was targetted by the United Steelworkers of America (USWA) as the company to set the example for contracts at Wabush Mines and Quebec Cartier Mining Company (QCM). The strike at IOC lasted 5 weeks, ending on April 27. The new contract is for 3 years and has no change in wage rates, but includes a "gain sharing" program which passes on to employees savings from productivity improvements. All transportation and cost of living allowance benefits were retained. Quebec Cartier Mining Company (QCM) settled without any work stoppage but employees at Wabush Mines were out on strike from March 25 to May 25. Wabush shipments were interrupted when stocks ran out in May.

Employment at Canadian iron ore mines, concentrators, agglomerating plants and support services was about 6740 at the end of the year as compared with 6900 in 1986 and 17 000 twelve years previous.

Exports approached 30 Mt and, as in the past several years, western Europe was the largest market for Canadian ore. Exports to the United States were down to 9 Mt in spite of resumption of operations at USX Corporation. The continuing drop was due to several factors but mainly to lower domestic iron ore prices in the United States. In addition, a number of blast furnaces were down for repairs, electric furnace mills continued to expand their market share at the expense of integrated mills and increasing use of continuous casting equipment reduced the amount of pig iron needed for each tonne of product manufactured. Continuous casting reduces the consumption of pig iron, and thus iron ore, in two ways; it increases the yield of product from molten steel and it reduces the amount of own-generated scrap. With less internally generated scrap, the mills purchase more scrap and a higher percentage of the iron units that are used are in the form of purchased scrap instead of iron ore.

Iron Ore Company of Canada (IOC) shipped 13.6 Mt of iron ore of which 7.8 Mt were acid pellets, 1.2 Mt were fluxed pellets, 3.4 Mt were concentrate and 1.2 Mt were blended Schefferville ores and Carol Lake concentrates. These shipments were distributed 60% to the open market and 40% to owners.

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The wet grinding mills that were installed at the end of 1986 at a cost of C$21 million were operated at 1500 t/h, 300 t/h above rated capacity. One dry grinding mill was operated during the year. The company's pellet plant was operated at capacity, with a slight drop in throughput when producing fluxed pellets.

Initiatives related to product diversification included a test shipment of low-silica fluxed pellets to Europe. Productivity improvement efforts were concentrated on recovery rates in the concentrator.

Employment levels were reduced during the year with a cut of 131 management positions. Hourly-paid employees were not affected. A three-year contract with the union was ratified on April 27.

Quebec Cartier Mining Company (QCM) sold about 16 Mt of ore in 1987, 15 Mt of which was produced during the year. The balance came from inventory, which was drawn down to minimum levels. The company had a wide mix of products, with many of them tailored to customer specifications. In particular, shipments included 7.8 Mt of pellets, of which most were normal acid grade but others were normal silica fluxed, low-silica fluxed, and low-silica acid grades. QCM also produces small quantities of special iron ore products such as high-silica concentrate, low-titanium (Ti)-low-phosphorus (P) concentrate, and low-Ti pellets. With these diverse products, the pellet plant has an apparent capacity of about 8.0 Mt/y and could produce more if it were running straight acid pellets. There was no summer shutdown in 1987.

A new deposit, named Mont Survie but formerly called baseline 'B', was in full operation in January 1987. It supplied almost 40% of the feed to the concentrator. The deposit has over 50 Mt of reserves, chiefly as hematite and grading 34% iron (Fe).

Production at Wabush Mines for the year was 5.2 Mt, representing 85% of capacity. Actions to reduce the manganese (Mn) content of its pellets, which had hindered their marketability to some steel plants, included selective mining and better silica control. In 1986 and 1987, the Mn content was lowered from about 2% to 1.65%; this action opened new markets, and some owners increased their take. Efforts to reduce Mn even further continued, building on tests begun in 1986. However, further reductions in Mn would probably require capital expenditures for new equipment. Efforts to increase productivity, which were focussed on refinements to the spiral concentrator, successfully increased yields by 3 to 5%.

Wabush took a trial delivery of 28 000 t of concentrate with an Mn content of 0.03% from QCM. This shipment was used to run tests on a blend of Wabush's own concentrate and the QCM material for the production of pellets with intermediate Mn content, but there were no long-term plans to pursue that program further.

Cleveland-Cliff Inc. (Cliffs) acquired Pickands Mather & Co. (P-M), the manager and one of the partners of Wabush Mines. The transaction involved a trade of Cliffs' oil and gas reserves, mainly in the western United States, for P-M's interests in two iron ore mines in the United States, Wabush Mines in Canada, Savage River Mines in Australia, five coal mines and P-M's research facility at Hibbing, Minnesota. Cliffs also manages Dofasco Inc.'s iron ore mines in Ontario.

The Algoma Ore Division of The Algoma Steel Corporation, Limited had a relatively good year and, in spite of a major restructuring in 1986 to reduce annual production to 900 000 t of sinter, produced 1.1 Mt in 1987. The mine shut down for the month of August but the sinter plant ran year-round. The Division's cost reduction plan continued throughout the year and included the use of larger diameter blast holes. Algoma faces contract negotiations with the USWA in 1988.

Dofasco Inc.'s two iron ore mines in northern Ontario, the Adams and Sherman, operated for eleven months in 1987 and produced over 1 Mt of pellets each for a total of 2.11 Mt. All of its mine product was fluxed pellets containing limestone and dolomite from Ontario quarries. Dofasco is totally committed to fluxed pellets from its own mines and IOC, primarily because it has obtained excellent results on material savings and higher efficiency in the blast furnaces. A ball mill for grinding flux was installed at the Sherman mine.

WORLD DEVELOPMENTS

The steel industry in the United States produced an estimated 74 Mt of crude steel in 1987 compared to 70 Mt in 1986. Booking orders into 1988 were strong and most capacity was sold to mid-1988.

In 1987, deliveries of iron ore to U.S. steel plants were up 12% from a year earlier and, at 59 Mt, were just below the deliveries in 1985. Most of the increase occurred in the third-quarter of the year.

U.S. imports of iron ore were down 0.3 Mt in 1987 and will likely continue to decrease in the future as prices of domestic ore become more competitive with offshore supplies.

Brazil was the second largest iron ore producer in the world again, after the Union of Soviet Socialist Republics, and was the world's largest exporter, surpassing Australia for the fourth year in a row. Brazilian exports of iron ore totalled 70.5 Mt during the first nine months of 1987 compared to 69.1 Mt in the same period of 1986.

Companhia Vale do Rio Doce (CVRD) in Brazil increased production from its Carajas mine to about 23.5 Mt in 1987. Although the planned capacity for the project is 35 Mt/y, the company has announced it will delay bringing Carajas to its full capacity until markets improve.

A fire in April at the 3 Mt/y Itabrasco pelletizing plant brought production to a halt. The damage was quite severe and production did not resume until June.

Minerações Brasileiras Reunidas SA (MBR) increased exports to 16 Mt/y in 1987 compared to 15 Mt in 1986. The company announced plans to expand production to 25 Mt/y by 1990 at a cost of US$60 million. These include an expansion at its mine in Aguas Claras, the construction of a new processing plant and the building of a new stacking system at its shipping terminal.

The resumption of construction on a new Brazilian railroad connecting Sepetiba Bay with MBR's iron ore deposits at Minas Gerais, which was begun 10 years ago and then abandoned, will be completed with financing from MBR's major shareholder and BNDES, the national development bank. Each party is to be responsible for 50% of the US$136 million investment required to finish the railway to Bora Mansa, Rio de Janeiro state, where it rejoins the existing track run by the federal railroad corporation (RFFSA).

MBR will be the main user of the line. RFFSA, which will operate the new line, will provide a 60% discount for 10 years for MBR's shipments, in consideration of its owner's investments. The discount will considerably lower MBR's transportation costs.

The steel industry in China was undergoing significant expansion and provided a promising market for internationally traded iron ore, especially from Australia.

Australian Prime Minister Hawks announced in June that Hamersley Iron Pty., Ltd. had reached agreement with the China Metallurgical Import and Export Corporation (CMIEC) for joint development of the Channar deposit. This joint venture, with capital cost estimated at $250 million and split 60/40 between Hamersley and CMIEC, was the culmination of three years of negotiation. Its plans call for the 200 Mt of high grade hematite ore to be developed as a satellite operation to Hamersley's existing mine at Paraburdoo, utilizing existing infrastructure. Mine development is to start early in 1988 and initial production at about 3 Mt/y is scheduled for 1990, with gradual buildup to a maximum of 10 Mt/y.

Eastern European countries expressed interest in sourcing high grade iron ore from western world suppliers to supplement or replace low grade ores from the Soviet Union. Agreements with eastern European countries generally involve counter trade.

Hancock Prospecting Pty Ltd. signed a memorandum of understanding with Czechoslovakia concerning the supply of Australian iron ore. The company will ship a 10 000 t trial batch for evaluation, prior to final price negotiations. Deliveries of 400 000 t in 1988 and 500 000 t in 1989 are expected.

The Broken Hill Proprietary Company Limited (B.H.P.) signed an agreement with Romania to supply 53 Mt of iron ore over the next 11 years. This agreement, estimated to be worth A$1.1 billion, includes bulk shipping priority rights through the Danube Canal and a commitment on the part of B.H.P. to spend A$25 million to install two modern ore handling facilities in Constanta to speed up unloading.

Japan, China, the Federal Republic of Germany and the Republic of Korea were the largest export markets for Australian iron ore in 1987.

Nigeria and Guinea agreed to form a new company with Liberia to develop the Guinean side of Mt. Nimba. The project was slated to reach capacity output of 12 Mt/y in 1990.

New mine developments that were completed in 1985 and 1986 brought India's iron ore production capacity to 70 Mt/y. Exports in 1986 were 32 Mt and Indian producers were planning to increase exports in 1987. India has replaced Canada as the fourth largest exporter of iron ore. India's chief markets are Japan, South Korea and Romania, but Indian exporters intend to expand into the western European market.

PRICES

Western Europe and Japan each take about one-third of the iron ore that is traded internationally. Buyers in Europe normally negotiate prices with the many exporters, including Canadian companies, in November and December for shipments that are contracted for the following calendar year. Japanese buyers negotiate their contracts in the January to March period for shipment during the Japanese fiscal year.

In the negotiations for 1987 contracts, however, the European buyers delayed settling until negotiations between the Japanese importers and most iron ore exporters were completed. This delayed settlement of nearly all contracts in both markets until April 1987. Price reductions occurred in most contracts.

In Japan, the price cuts were mainly in the range of 5 to 6%. Canada's Carol Lake concentrate price was cut by 5.3%. The biggest reductions were for South African ores, which were 6.6% and 6.8% for lump and fines respectively.

Price reductions on fines, for European delivery, reached 11.1%. Although Canadian exporters accepted a 9.3% cut for concentrates, pellet prices were marginally higher and IOC got a 1.8% price raise for these. Brazilian pellet producers were able to negotiate raises of 3.1% and 4.6%.

Overall, prices have fallen every year since 1982 and the cumulative effect has been a decline of 25% in terms of US¢/Fe unit.[1] For some exporters, the devaluation of their national currencies has meant that the prices for them have not been seriously eroded. During 1987, however, the U.S. dollar weakened considerably relative to many currencies and some exporters, especially the Australians, were feeling the effects of the U.S. dollar denominated price declines of the past five years.

By year-end 1987, a contract for 1988 deliveries had been negotiated between Australia's B.H.P. and a group of Japanese mills for Mt. Newman ore. This contract maintained the volume of deliveries and the price of lump ore at 1987 levels, but cut the price for fines by 4%.

Price negotiations for 1988 deliveries commenced later than usual in Europe. The early indications were that the development of a tight supply situation for pellets would lead to further strengthening of pellet prices and the difference between pellet and concentrate prices would be re-established at 12¢/Fe unit.

The market for concentrates and fines in Europe remained soft at year-end and exporters were not expecting to gain a significant price increase for 1988.

UNCTAD DIALOGUE ON IRON ORE

The current series of intergovernmental meetings on iron ore is in the context of the Integrated Programme on Commodities (IPC) that was adopted by the United Nations Conference on Trade and Development (UNCTAD) in 1976. Since then, four preparatory meetings have been held to determine whether a basis could be established for negotiating stabilization actions for iron ore trade. As these meetings failed to reach a consensus on what type of actions would be suitable, participating countries agreed in 1985 to establish an Intergovernmental Group of Experts on Iron Ore (IGE). The IGE was given a mandate to meet in two sessions, with the first to be held in 1986 and the second in 1987, to review market developments in iron ore, and to report thereon to the Fifth Preparatory Meeting.

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[1] Price is reported in cents, United States currency, for each percentage point of iron in a t of ore; e.g. at 30¢/Fe unit, ore grading 65% iron would bear a price of 65 x 30¢ = US$19.50/t.

The first session of the IGE was held in October 1986. It made considerable progress in developing a new statistical questionnaire and in exposing many problems and issues in the iron ore industry. The second session, scheduled for November 1987, was postponed to March 1988.

DIRECT REDUCTION

Sidbec operated its Midrex module at close to capacity of 750 000 t/y in 1987.

By the end of 1987, 60 direct reduction plants had been constructed in the world. Production reached 23.62 Mt of iron, a 15% increase from the 21.62 Mt of 1986. This increase was attributed to improved plant production and startup of additional capacity in India, New Zealand, Egypt and the Soviet Union. In March 1987, a letter of intent to build a new Midrex plant of 400 000 t/y capacity, located near Puerto Ordaz, Venezuela, was announced by Siderurgica Venezolana, S.A. (SIVENSA).

OUTLOOK

Massive restructuring of the steel industry in recent years, particularly in the United States, had a major impact on the strategies and perspectives of Canadian iron ore producers. A major benefit of the changes was increased orders for iron ore from owners of Canadian mines in 1987 due to a combination of lower price, better quality and an improvement in demand for steel in the United States. The Iron Ore Company of Canada (IOC) benefitted from a reorganization that lowered the cost of iron ore to its owners and facilitated offshore sales. M.A. Hanna Company, its marketing agent, was given much more latitude in selling to third parties; it could sell at world prices and offer guarantees for long-term delivery to new customers. As a result, IOC has reportedly contracted to sell all the pellets it can produce in 1988. Unfortunately, the market for fines is so saturated that shipments of unpelletized products from IOC and QCM will likely decline in the short term.

Canadian iron ore producers continued to cooperate closely with consumers to develop products that are tailored to specific user needs. Self-fluxed pellets for Dofasco Inc. and Bethlehem Steel Corporation, high-silica concentrate for European steelmakers and low-silica pellets for European and North American consumers, as well as a significant reduction of manganese in Wabush pellets are examples of efforts to improve access to markets. All exporting companies have plans to continue to improve their product lines.

The production of iron ore in Canada is forecasted to remain in the 35 to 40 Mt/y range for the medium term. The proportion of acid pellets, self-fluxed pellets, pellets with specific manganese and silica content, and products not yet available will increase relative to concentrate sales. Self-fluxed pellets will increase market share at the expense of acid pellets.

Employment in the industry is not likely to increase but the restructuring that produced a 50% drop in the past 10 years is now essentially complete and no more massive layoffs are expected in the near term.

In the short term, the surplus in the market of iron ore fines and concentrates is working to the advantage of steel mills with large sinter plants, such as the majority of mills in Europe and Japan. Late in December 1987, the Japanese mills contracted price cuts of 4 - 4.6% with three of their Australian suppliers of iron ore fines. These price cuts will likely set the precedent for all fine ore and concentrate contracts for Japan in 1988. Moreover, since the price is set in terms of U.S. currency, the price cuts are an additional benefit to the savings from changes in the exchange rate of the Japanese yen. From a Japanese perspective, the costs of both iron ore and coal will be lower in 1988.

Major exporters of iron ore are finding growing markets in two areas of the Socialist Blocs. The eastern Europe market has been expanding as steel plants look for high grade iron ore to improve the quality of their steel by using blends of Australian, Canadian, Brazilian or Indian iron ore with ore from the U.S.S.R. There are also rumours that some Russian mines are now considered too costly to run and the eastern European steelmakers are being encouraged to find other sources of supply. The Australian government and industry completed a tour of eastern Europe in 1987 and reported further progress on the arrangement with Romania and improved prospects for sales in Czechoslovakia, Hungary and the U.S.S.R.

The steel program in the People's Republic of China (PRC) will require significant quantities of foreign iron ore in the near term to meet production targets. In the long term, the Chinese plan to exploit their extensive domestic iron ore reserves, but they recognize that blending of imported ore with their own resources may be the cheapest way to produce consistent runs of high grade steels. Their joint venture regarding the Channar deposit in Australia would only satisfy part of that potential requirement and other countries and corporations are approaching the PRC to arrange what may develop into major iron ore trade.

Canadian mines, because of their recent improvements in productivity, should be able to take advantage of some of these market opportunities and maintain their current volume of sales and production. The tight market for pellets should also improve the profitability of Canadian mines in the short term.

TABLE 1. CANADA, IRON ORE PRODUCTION AND TRADE, 1986 AND 1987

	1986		1987	
	(tonnes)[1]	($000)	(tonnes)[1]	($000)
Production (mine shipments)				
Newfoundland	19 465 064	702 483	18 774 800	685 423
Quebec	13 200 000	C	15 500 000	C
Ontario	3 366 807	C	3 213 600	C
British Columbia	63 700	3 442	64 000	2 313 000
Total[2]	36 095 571	1 254 758	37 552 400	1 254 247
Imports			(Jan. - Sept.)	
Iron ore				
United States	2 959 672	176 614	3 260 263	165 431
Brazil	452 842	14 855	171 304	5 329
Japan	5 000	107	181	14
Italy	51	4	13	1
Total	3 417 565	191 580	3 431 761	170 775
Exports				
Iron ore, direct shipping				
United States	564 089	28 783	116 158	2 076
United Kingdom	683 084	21 207	94 839	1 802
Netherlands	54 780	1 753	0	0
Italy	106 750	1 987	0	0
Germany, West	92 320	2 954	0	0
Total	1 501 023	56 684	210 997	3 878
Iron ore, concentrated				
Germany, West	2 188 248	50 492	1 343 153	28 209
United Kingdom	1 424 718	30 262	1 381 750	27 176
France	1 894 401	42 022	1 268 417	24 559
Japan	2 076 192	44 476	1 208 043	23 791
Netherlands	1 884 252	43 555	735 499	16 635
Italy	458 076	10 326	488 189	10 321
United States	634 797	13 050	334 485	6 984
Belgium-Luxembourg	304 612	6 928	270 515	5 716
Philippines	221 059	4 642	266 906	5 700
Austria	238 407	4 940	208 497	3 665
Pakistan	238 472	4 921	129 665	2 570
Korea, South	137 992	2 768	136 477	2 379
Portugal	171 616	4 247	84 874	1 865
Spain	57 121	1 347	55 000	1 178
Romania	0	0	49 537	964
Yugoslavia	75 347	2 491	0	0
Total	12 005 310	266 467	7 961 007	161 712

TABLE 1. CANADA, IRON ORE PRODUCTION AND TRADE, 1986 AND 1987 (cont'd)

	1986		Jan. - Sept. 1987	
	(tonnes)[1]	($000)	(tonnes)[1]	($000)
Iron ore, agglomerated				
United States	8 249 746	466 184	5 588 673	278 273
United Kingdom	3 705 455	119 497	3 728 675	120 160
Italy	965 762	45 512	781 609	37 310
Germany, West	1 709 292	54 815	1 014 326	32 919
Netherlands	1 425 211	47 561	624 607	21 369
France	360 631	11 201	439 211	13 572
Belgium-Luxembourg	590 486	23 362	183 900	7 940
Portugal	173 460	5 690	205 021	6 224
Japan	0	0	300 787	5 715
Spain	55 006	2 037	119 536	3 741
Austria	102 631	3 334	92 290	2 958
Yugoslavia	151 277	5 202	0	0
Total	17 488 957	784 395	13 078 635	530 181
Iron ore n.e.s., including by-products				
United States	12 950	216	16 893	330
Total	12 950	216	16 893	330
Total exports, all classes				
United States	9 461 582	508 038	6 056 209	287 663
United Kingdom	5 813 257	170 966	5 205 264	149 138
Netherlands	3 364 243	92 869	1 360 106	38 004
West Germany	3 989 860	108 261	2 357 479	61 128
Italy	1 530 588	57 825	1 269 798	47 631
France	2 255 032	53 223	1 707 628	38 131
Belgium-Luxembourg	895 098	30 290	454 415	13 656
Japan	2 076 192	44 476	1 508 830	29 506
Portugal	345 076	9 937	289 895	8 089
Yugoslavia	226 624	7 693	-	-
Austria	341 038	8 274	300 787	6 622
Philippines	221 059	4 642	266 906	5 700
Pakistan	238 472	4 921	129 665	2 570
Spain	112 127	3 384	174 536	4 919
Other countries	137 992	2 768	186 014	3 343
Total	31 008 240	1 107 762	21 267 532	696 101
Consumption of iron ore at Canadian iron and steel plants	14 185 304	..	14 744 532	..

Sources: Energy, Mines and Resources Canada; Statistics Canada; American Iron Ore Association.

[1] Dry tonnes for production (shipments) by province; wet tonnes for imports and exports.

[2] Total iron ore shipments include shipments of by-product iron ore.

P Preliminary; C Withheld to avoid disclosing company proprietary data; - Nil;
.. Not available; n.e.s. Not elsewhere specified.

TABLE 2. CANADA, IRON ORE PRODUCTION (SHIPMENTS), 1984-87

Company and Location	Ore Mined	Product Shipped	1984	1985	1986	1987P
			(000 tonnes, natural or wet)			
Adams mine, Kirkland Lake, Ont.	Magnetite	Acid Pellets	1 105	1 141	-	-
		Fluxed Pellets			971	1 000
Algoma Ore division of The Algoma Steel Corporation, Limited Wawa, Ont.	Siderite	Sinter	1 280	1 382	1 186	1 100
Griffith mine, Bruce Lake, Ont.	Magnetite	Pellets	954	789	160	-
Iron Ore Company of Canada Schefferville, Que.	Hematite, goethite and limonite	Direct shipping	1 525[1,2]	1 830[1,2]	1 421[1,2]	1 200
Carol Lake, Lab.	Specular hematite and magnetite	Concentrate	5 753	4 997	3 858	3 400
		Acid Pellets	7 956	8 168	9 140	7 800
		Fluxed Pellets	-	-	1 152	1 188
Sept Îles, Que.	Schefferville "treat ore"	Pellets	303[2]	-	-	-
Quebec Cartier Mining Company, Mount Wright, Que.	Specular hematite	Concentrate	9 898	8 619	6 947	8 175
		Acid Pellets	-	6 638	5 448	7 125
		Fluxed Pellets			1 384	900
Sidbec-Normines Inc. Fire Lake, Lac Jeannine, and Port Cartier, Que.	Specular hematite	Concentrate	-	-	-	-
		Pellets	4 883	-	-	-
Sherman mine, Temagami, Ont.	Magnetite	Acid Pellets	1 015	474	-	-
		Fluxed Pellets	-	524	1 036	1 000
Wabush Mines, Wabush, Labrador and Pointe Noire, Que.	Specular hematite and magnetite	Pellets	6 319	5 696	5 293	5 400
British Columbia Producers	Magnetite	Pellet Feed, Magnetite Concentrate	155[2]	87[2]	51[2]	64[2]
Other Ontario	Pyrrhotite, magnetite	Pellets, Magnetite Concentrate	187	140	-	-
			41 333	40 485	38 047	38 352

[1] Includes some Carol Lake concentrate. [2] Stockpile ore.
P Preliminary; - Nil.

TABLE 3. RECEIPTS AND CONSUMPTION OF IRON ORE AT CANADIAN IRON AND STEEL PLANTS, AND INVENTORIES, 1986 AND 1987

	1986	Jan.-Oct. 1987
	(000 tonnes)	
Receipts imported	5 570	4 170
Receipts from domestic sources	8 816	7 345
Total receipts at iron and steel plants	14 386	11 516
Consumption of iron ore	14 185	12 545
Inventory at docks, plants, mines and furnace yards, December 31	9 927	7 713
Inventory change	-1 252	-2 214

Source: American Iron Ore Association.

TABLE 4. WORLD IRON ORE PRODUCTION, 1984-86

	1984	1985	1986[e]
		(000 tonnes)	
U.S.S.R.	247 100	247 640	250 000
Brazil	112 100	128 200	132 000
Australia	91 640	96 430	95 600
People's Republic of China[e]	121 900	131 500	142 400
India	40 760	42 550	48 820
United States	52 100	49 530	39 610
Canada	41 333	39 880	37 300
Republic of South Africa	24 650	24 390	24 480
France	15 030	14 480	12 560
Liberia	16 100	16 120	15 600
Sweden	18 120	20 270	20 480
Venezuela	13 060	14 760	16 720
Other countries	81 057	78 630	79 030
Total	874 950	904 380	914 680

Source: Association of Iron Ore Exporting Countries (APEF).
[e] Estimated.

TABLE 5. CANADIAN CONSUMPTION OF IRON-BEARING MATERIALS BY INTEGRATED[1] IRON AND STEEL PRODUCERS, 1986

	Consumed In				
			Iron and Steel Furnaces		
Material Consumed	Sinter Plants at Steel Mill	Direct Reduction Plants	Production of Pig Iron	Steel Furnaces	Total in Furnaces
			(tonnes)		
Iron Ore					
Crude and concentrate	234 946	207 000	58 635	-	58 635
Pellets	72 179	811 500	11 353 110	6 502	11 359 611
Sinter	96 349	-	1 094 896	-	1 094 896
Sinter produced at steel plant	-	-	809 415	-	809 415
Direct reduced iron	-	-	-	663 292	663 292
Other iron-bearing materials including flue dust, mill scale, cinder, slag, etc.	352 030	-	322 718	112 904	435 622
Total	755 503	1 018 500	13 638 774	782 698	14 421 472

Source: Company data.
[1] Dofasco Inc.; Sidbec-Dosco Inc.; Sydney Steel Corporation; The Algoma Steel Corporation, Limited; Stelco Inc.
- Nil.

TABLE 6. NORTH AMERICAN PRICES OF SELECTED ORES AT YEAR-END, 1975, 1980 AND 1983-87

	1975	1980	1983	1984	1985	1986	1987
				($US)			
Mesabi Non-Bessemer[1]	18.21	28.05	32.25-32.53	30.03-31.53	30.03-31.53	30.03-31.53	30.03-31.53
Old Range Non-Bessemer and Manganiferous[1]	18.45	28.30	32.78	32.78	32.78	32.78	32.78
PELLETS: (per gross ton iron unit)[2]							
Lake Erie Base Price[3]	0.464	0.725	0.805-0.869	0.805-0.869	0.869	0.869	0.7245-0.869
USX Corporation[4]	-	-	-	-	-	-	0.037344
Upper Lakes[5]	-	-	-	-	0.594	0.594	0.4684-0.594
Wabush[6]	-	0.635	0.635	0.635	0.635	0.635	0.635
Mineral Services Inc.[4]	-	-	-	0.660	0.580	0.580	0.580
Direct Reduced Iron[7]	-	-	115-135	115-135	115-135	115-135	115-135

Sources: Skillings Mining Review; Iron Age.

[1] US$ per gross ton, 51.5% of iron natural, at rail of vessel, lower lake ports. [2] US$ per gross ton natural iron unit. One iron unit equals 1 percentage point of iron content in a ton of ore; an ore containing 60% iron, therefore, has 60 iron units. [3] Cleveland-Cliff Inc., M.A. Hanna Company, Oglebay Norton Co. at rail of vessel lower lake port. [4] At mine.
[5] Pickands Mather & Co. and Inland Steel Mining Co. in hold of vessel upper lake port. [6] F.o.b. Pointe Noire.
[7] US$ per tonne.
- Nil.

TABLE 7. SELECTED PRICES OF IRON ORE BOUND FOR JAPAN AND EUROPE 1981-87

Ore	Market	Source	1981	1982	1983	1984	1985	1986	1987
				(U.S. cents per Fe Unit Dmt, f.o.b.)					
Fines (including concentrate)	Europe	CVRD	28.1	32.5	29.0	26.15	26.56	26.26	24.50
		Iscor	26.9	31.4	27.9	20.6	23.5	22.7	-
		Kiruna	33.0	34.7	30.1	27.7	28.5	27.9	25.93
		Carol Lake	29.3	33.0	29.3	26.8	26.8	26.5	24.03
		Mt. Wright	29.75	33.0	29.3	26.8	26.8	26.5	24.03
	Japan	CVRD	26.9	30.5	27.5	24.27	24.65	23.66	22.24
		Iscor	26.9	30.5	27.0	23.89	22.26	20.55	19.15
		Hamersley	29.7	34.2	30.5	26.67	27.05	25.97	24.67
		Carol Lake	27.0	29.8	26.7	23.37	23.37	22.44	21.25
Lump	Europe	Iscor	31.9	35.9	31.3	24.0	29.0	26.7	-
		Hamersley[1]	42.45	44.75	38.15	36.15	38.48	36.2	33.15
	Japan	CVRD	26.9	30.5	27.9	24.27	24.65	23.66	22.24
		Iscor	30.9	35.0	30.6	27.19	25.86	23.91	22.34
		Hamersley	34.2	40.0	34.9	30.87	31.55	30.29	28.78
Pellets	Europe	CVRD	43.1	47.5	39.0	36.0	36.0	35.6	36.7
		Kiruna	48.5	50.2	41.0	38.6	38.6	38.15	41.15
		Carol Lake & Pt. Cartier	-	-	-	-	36.5	36.5	37 15
	Japan	CVRD (Nibrasco)	55.2	53.6	42.9	37.31	36.25	35.29	35.6
		Savage River	48.9	53.4	-	38.3	37.1	36.02	34.72

Sources: The Tex Report, Metal Bulletin and Japan Commerce Daily.

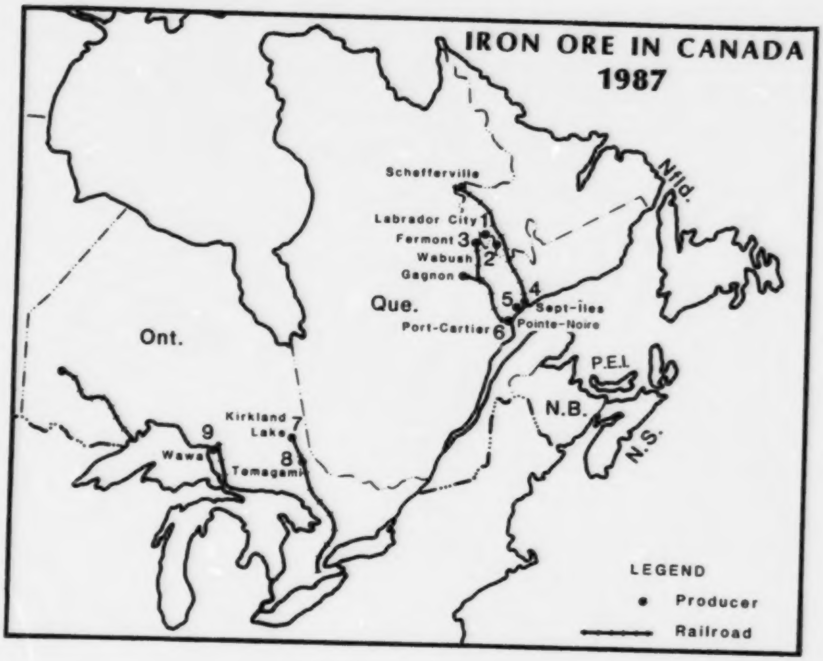
[1] C.i.f. Rotterdam.

- Not available; Dmt Dry metric tonne; f.o.b. Free on board.

TABLE 8. CAPACITY AND PRODUCTION OF DIRECT REDUCED IRON (DRI), 1986

Country	Capacity (million tpy)	Production (million t)
Argentina	0.93	0.95
Brazil	0.32	0.30
Burma	0.04	0.03
Canada	1.00	0.69
Egypt	0.73	0.03
India	0.30	0.17
Indonesia	2.30	1.30
Iran	0.73	0.00
Iraq	0.49	0.00
Malaysia	1.32	0.58
Mexico	2.03	1.37
New Zealand	0.87	0.26
Nigeria	1.02	0.11
Peru	0.10	0.06
Qatar	0.40	0.49
South Africa	1.11	0.79
Saudi Arabia	0.80	1.17
Sweden	0.07	0.00
Trinidad	0.84	0.38
United Kingdom	0.80	0.00
United States	0.40	0.16
U.S.S.R.	1.25	0.75
Venezuela	4.50	2.92
West Germany	1.28	0.17
Total	23.62	12.65

Source: Midrex Corp., North Carolina, United States.



IRON ORE IN CANADA
1987

Schefferville
Labrador City 1
Fermont 3
Wabush 2
Gagnon
5 4
Sept-iles
Port-Cartier 6
Pointe-Noire
Que.
Nfld.
Ont.
P.E.I.
N.B.
N.S.
Kirkland Lake 7
9
Wawa
8
Temagami
LEGEND
● Producer
Railroad

PRODUCERS
(numbers refer to numbers on map above)

1. Iron Ore Company of Canada, Carol Division (mine/concentrator/pellet plant)

2. Wabush Mines (mine/concentrator)

3. Quebec Cartier Mining Company (mine/concentrator)

4. Iron Ore Company of Canada (port)

5. Wabush Mines (pellet plant/port)

6. Quebec Cartier Mining Company (pellet plant/port)

7. Dofasco Inc., Adams mine (mine/concentrator/pellet plant)

8. Dofasco Inc., Sherman mine (mine/concentrator/pellet plant)

9. Algoma Ore division of the Algoma Steel Corporation, Limited (mine/concentrator/sinter plant)

Iron and Steel

R. McINNIS

OVERVIEW

The Canadian steel industry benefitted in 1987 from good levels of consumer spending and a significant rise in the level of capital expenditures. Canadian production at 14.7 Mt was up 4.5% in 1987 compared to 1986.

Crude steel production, as reported by the International Iron and Steel Institute (IISI), for 30 western world countries increased 2.4% in the first 11 months of 1987 to 392.9 Mt. Starting from a slow first quarter, rates of production trended upwards in the second and third quarters.

In the United States, production for 1987 was 79.8 Mt, up 7.8% from 1986. A large part of this increase was due to substitution of domestic steel for imports and a stronger domestic demand for steel.

In the European Economic Community (EEC), steel production in the first eleven months was 115.2 Mt, 0.3% lower than in the same period last year. Imports of steel, which accounted for about 13% of the market, were lower while exports were somewhat higher.

In most non-EEC European countries, changes in the level of steel production in the first eleven months of 1987 were small compared to 1986, except for Switzerland where output fell some 20% and in Turkey where production increased by about 17%.

Crude steel production in Japan in 1986 was 98.5 Mt, up slightly from the 98.3 Mt produced in 1986. Although total domestic steel demand was higher, exports were down some 13% due to the appreciation of the yen. These factors also stimulated a 30% increase of steel imports, to about 7% of the domestic market.

There was some firming of steel prices during the year, but uncertainty about future demand in a number of major steel intensive sectors limited increases.

Government actions continued to have an impact on trade in steel. The United States extended the duration for tariffs and quotas on specialty steel, and continued to limit imports of carbon steel by voluntary restraint agreements with its trading partners. In Canada, steel was placed on the import and export control list for purposes of monitoring. Production quotas were used by the EEC on many steel mill products, and imports were controlled by bilateral agreements.

The restructuring of the world steel industry continued, with major reductions of production capacity in Japan and lesser reductions in other nations. In North America and Europe, major reductions of capacity had been made in recent years and more reductions, especially in Europe, are expected in the future. Newly industrialized nations continued to expand capacity.

CANADIAN DEVELOPMENTS

The Canadian steel industry's production was significantly higher in 1987 than in 1986. Production of crude steel totalled 14.7 Mt, a 4.5% increase over the 14.1 Mt reported for 1986.

Capacity utilization rates at steelmaking furnaces were not directly comparable for the past two years as the industry's annual capacity was reduced to 18 641 480 t in January 1987. This reduction was due primarily to the closure of open hearth furnaces at Stelco Inc.'s plants in Hamilton. In 1986, annual capacity was 20 049 703 t.

Canada continued to be a net exporter of steel. Exports totalled 2.33 Mt in the first nine months of 1987 compared to 1.90 Mt in the corresponding period of 1986. The increase was due partially to a six-month strike at USX Corporation in the United States. Imports of steel increased slightly in the first nine months to 1.86 Mt, an 8.6% increase compared to 1986. The main factor affecting imports was the continuing world surplus of steel.

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Integrated Steel Companies

The Algoma Steel Corporation, Limited. Algoma was profitable during the first nine months of 1987 for which information was available. Its profitability was attributed mainly to substantial reductions in production costs in mining and steelmaking, and partially to a slightly higher volume of production. The company advanced on its goal to continuously cast all of its steel.

Capital expenditures of approximately $100 million were committed during the year.

The company's new seamless tube mill started making the full range of sizes during the first quarter of 1987. An increase in oil exploration in the last half of the year spurred sales.

The company and the United Steelworkers of America completed their collective bargaining and ratified a new contract, effective August 1, 1987, without a work stoppage. This one-year contract fixed employment costs at July 31, 1987 levels.

Dofasco Inc. Dofasco's sales revenues improved considerably during the year. These revenues were generated on sales of less tonnage than in the previous year, which was made possible by a greater proportion of higher valued products and higher selling prices.

Capital expenditures for new plant equipment totalled $216 million to June 30. Most of this expenditure was for the cast slab facilities, which were brought on stream in stages during the remainder of the year. A program to upgrade galvanizing facilities was also under way during the year.

Sidbec-Dosco Inc. Sales for the first three and six months increased 20% and 16%, respectively, compared to the same periods in 1986. The company's profits were higher than in the previous year.

Raw steel production was 898 000 t in the first nine months compared to 858 000 t in the same period of the previous year. Capital expenditures for the year were mainly for the installation of automatic speed controls at the Longueuil merchant mill.

The strike that closed plants in Contrecoeur, Montreal and Longueuil, Quebec ended in November with a new contract that included wage increases and a profit sharing plan.

Stelco Inc. Net sales for the first six months increased about 20% to $1 287.8 million. Shipments increased 47 000 t to 2 146 000 t and manufacturing facilities operated near capacity.

Early settlements on new labour contracts were ratified by all locals of the United Steelworkers of America. The new three-year contracts began August 1, 1987.

Capital spending intentions in 1987 were valued at $125 M. A major new project was a $54 M vacuum degassing plant at the Lake Erie works.

The Edmonton works was seriously damaged by a tornado in August. Repairs were completed and the plant returned to full production by November.

Stelco's multi-year modernization program was completed during the year. The first of two continuous casting machines at the Hilton Works was started up in July and the second was started in September.

On June 19, Stelco Inc. and Armco, Inc. announced the formation of a new company, ME International, which will manufacture cast grinding media and mill liners for the mining industry. ME International will combine the assets of three existing companies in the north-central United States.

Stelco Inc. announced in December that it will restructure its operations on January 1, 1988 into Stelco Steel, charged with steel making activities, and Stelco Enterprises, responsible for downstream products through existing business units, new joint ventures and acquisitions. These new groups will be stand-alone operations, each with its own president and each reporting directly to Stelco Inc.

Sydney Steel Corporation (Sysco). Sydney Steel shipped 156 000 t of steel in 1987, a similar quantity to 1986. Shipments of rails totalled 152 000 t, of which 120 000 t were destined for export markets.

Sysco will proceed with the second and third stages of its modernization program. This will include the installation of an electric arc furnace, a contiuous bloom caster, an universal rolling mill, ladle refining and vacuum degassing apparatus and equipment for head hardening rails.

The total cost of the modernization program will exceed $250 M. Completion is scheduled for 1990.

Electric Furnace Mills

Co-Steel Inc. The company's consolidated sales and revenues increased by 30% in the first nine months of the year. At the Lasco plant in Whitby, Ontario, shipments increased in March and the company increased production to full shift operations in most of its plants. First quarter shipments were 2% lower than for the same period in 1986. The second quarter, however, was up 8% compared to the second quarter of 1986. Lasco has begun operating a new car shredder. The company's Sheerness plant in Scotland was in the process of upgrading its melt shop.

IPSCO Inc. IPSCO posted a loss during the first six months of 1987. A contributing factor was lower sales to the energy sector, which were only two-thirds that of the previous year when 25 000 t of large-diameter oil transmission pipe were sold. There was, however, a three-fold increase in sales of oil well casing and tubing, and small diameter line pipe. Steel operations ran at 63% of capacity while pipe facilities were used at only 33% of capacity. Although total steel shipments were higher in 1987, there was a shift to lower-valued flat rolled steel. The company, nevertheless, proved that it could compete in the latter market. Labour contracts expired in July 31, 1987.

The company's new continuous slab caster, which cost $65 million, made its first cast on May 11, 1987. That initial trial was a complete success and commissioning of the equipment proceeded towards regular production.

IPSCO concluded an agreement for the sale and lease-back of certain of its steel division production equipment, including the continuous caster. The sale resulted in a gain of $23.2 M. Its lease, terminating in 2007, will be shown as an annual operating expense. The funds thus obtained are to be used to purchase and retire the company's first mortgage bonds, which will result in a significant interest saving, and to assist in undertaking capital projects or acquisitions that are directed towards market diversification.

Manitoba Rolling Mills. AMCA International Limited's restructuring program, announced in 1986, included the sale of its subsidiary, Manitoba Rolling Mills. Effective December 30, 1987 the sale was made to The Canam Manac Group Inc.

A modernization program that began in 1986 was virtually completed in 1987. The company increased its line to approximately 600 products. Efforts to improve product quality and plant productivity by the use of statistical process control and computers in the rolling mill were very successful.

Initial market response to the new products was excellent, with the company's super-light beams displacing imports, especially in the truck and trailer industry.

QIT-Fer et Titane Inc. QIT announced a $130 million expansion program at its ilmenite mining and smelting facilities in Quebec. The program includes the modernization of two of its nine electric furnaces at Sorel to match the higher power rating of recently installed furnaces. The expansion will increase plant capacity by 150 000 t/y of iron and 170 000 t/y of 80% titanium dioxide slag. Total capacity will be 1.0Mt/y of titanium dioxide slag and 860 000 t of iron. The company's new steel plant (oxygen converter and continuous casting machine), with a 400 000 t/y capacity, was fully operational.

Specialty Steel Mills

Atlas Steels. The combined earnings of the steel manufacturing companies of Rio Algom Limited, including Atlas Stainless Steels, Atlas Specialty Steels and AL Tech Specialty Steel Corporation were higher than in the previous year. The major capital expenditures in 1987 were for continuous casting equipment at Welland, Ontario.

On May 12, Rio Algom announced an agreement with Barlite Corporation Limited, a publicly listed Australian corporation, to combine the two corporations' Australian metal manufacturing and distribution businesses into a new company. It will be owned 51% by Rio Algom, 20% by Barlite and 29% by the public.

Slater Industries Inc. Sales from steel producing divisions were down slightly in the company's fiscal year, ending March 31, 1987 and consolidated net sales were up 19%, an increase that reflected the acquisition of newly acquired companies. To September 30, 1987 sales were $157 M compared to $127 M in the same six months period of 1986.

In March 1987, the company acquired the Norforge Division of Tecsyn Canada Ltd. at Sept Îles, Quebec. This company manufactures forged grinding balls for the mining industry. It will complement Slater's existing steel mill and forging facility that also makes grinding balls in Hamilton, Ontario and it will create a new market for bar products manufactured by the company's Specialty Bar Division. The company's capital expenditures were committed primarily to the acquisition of a new rolling mill for the Fort Wayne Specialty Alloy Division. The new mill was scheduled for operation in the summer of 1988. Construction was on schedule and on budget.

WORLD DEVELOPMENTS

The International Iron and Steel Institute reported that steel production from companies in 30 countries, representing 98% of western world production, was 279.6 Mt in the first eight months of 1987. This production was 0.3% below the 280.6 Mt produced during the same period in 1986.

In the United States, production for the first nine months was up 3.2% at 63.5 Mt. This increase was partially due to the restarting of the USX Corporation operations after a six month strike that ended in January 1987. The pressure from imported steel was reduced somewhat by the lower value of the U.S. dollar and President Reagan's steel program. Imports dropped by 6% in the first six months of 1987. The Voluntary Restraint (VRA) program had the effect of guaranteeing signatory countries a share of the U.S. market and exempted them from dumping and countervailing actions. Thus, the U.S. industry may not have benefited fully from the declining dollar.

The U.S. steel industry continued to struggle with excess capacity. During the period July 1, 1986 to June 30, 1987, employment in the industry declined by 16% to 148 000 persons while labour productivity increased by about 6%. The number of person-hours/t of steel shipped fell from 5.1 to 4.8, a lower level than either Japan or West Germany. Capacity was reduced by 9.8%, partially due to the complete shutdown of two companies. The amount of steel produced by continuous casting increased by 2.5% to 47.5% of 1987 U.S. production. This equipment required a significant capital investment in the recent past and the tappering off of investment on this technology may partially explain the 36% decline in capital expenditures, to $1.2 billion, in 1987.

U.S. protectionist sentiment for the domestic steel industry was very high during the year, and there was much concern that no VRAs had been negotiated with Canada, Sweden and Taiwan. Exports from these countries were closely monitored. In this regard, legislation was introduced to Congress and the House of Representatives on September 17 for the purpose of limiting steel imports from Sweden, Taiwan and Canada to 70% of the level of imports that entered the United States from these countries in the 12 months prior to October 1, 1984, unless a VRA was agreed to within 90 days of enactment of the bill.

The United States also extended import relief for specialty steel until September 30, 1989. This trade action, in effect since July 5, 1983, was designed to limit imports through a system of import duties and quotas. Under the terms of the three-year extension, stainless steel sheet, strip and plate will continue to be subject to a tariff, but it will decrease from 3% in the first year to 2% in the second, and to 1% in the third.

For stainless steel bars and wire rod, and for alloy tool steel bars, wire rod, plates, sheet and strip, global quotas will still be enforced but they will be allowed to increase each year. The quotas allowed to each country are to be established by bilateral consultations or, failing agreement, could be imposed unilaterally. Canada agreed to an Orderly Marketing Agreement (OMA) for the period October 20, 1987 to September 30, 1989. The items that were included in this agreement were stainless steel bars and, alloy tool steel bars, wire rods, plates, sheets and strip. Other countries that have concluded Orderly Marketing Agreements are Japan, Korea, Mexico, Spain, Sweden and Taiwan.

Japanese exports fell 13% in the first six months to 12.6 Mt. In the first nine months, Japanese production declined by 2.7% to 71.6 Mt. All five major steel producers recorded losses. By year-end, production was up slightly compared to 1986.

Japan's substantial surplus capacity motivated its management to rationalize operations. Production in 1990 was forecasted to be 90 Mt, compared to the 96 Mt produced in 1986, while current capacity is estimated to be 138 Mt. Since November 1, 1986, Japanese companies have closed eight blast furnaces, with a resultant loss of about 40 000 jobs or some 30% of the workforce.

Production and exports of steel from Japan continued to be affected by the appreciation of the yen, which lowered the steel industry's cost competitiveness and allowed imported steel to increase its share of the domestic market by 33% in the first six months. Japanese steelworker wages are seven times that of workers in South Korea. The domestic demand for steel was also affected by the value of the yen because steel intensive products, such as cars, were less price competitive in the export market. However, the government took measures to stimulate domestic demand, which resulted in a 1.6% increase of domestic orders in the first six months compared to the same period in 1986.

Japan's steel industry has continued to upgrade its product mix by shifting to higher-valued steel grades and manufactured products. The Japanese steel companies have also diversified into other businesses, partly to find jobs for workers displaced by restructuring in the industry. This diversification will be facilitated by the large cash reserves held by the major companies.

Some of the main developments in 1987 for the major Japanese steel companies were the following.

Nippon Steel Corporation announced that it would reduce annual capacity by 10 Mt to 24 Mt, and planned to cut 19 000 people from its workforce of 65 000.

Kawasaki Steel Corporation reported that it was planning to suspend operations of its plate mill and one hot rolling mill at Chiba, and that it may decide to completely close the Chiba Works. Its work force of 26 000 is expected to decline by 5 000 people.

Sumitomo Metal Industries, Ltd. plans to trim capital expenditures and to cut 6 000 of 27 000 jobs.

Nippon Kokan KK has announced a decision to suspend production of some items at its Keichin works and to reduce its work force of 30 000 by 7 000, 6 000 from steelmaking and 1 000 from shipbuilding.

Kobe Steel Corporation plans to reduce its steelmaking labour force of 28 000 by 6 000, but will seek to avoid layoffs by shifting into other activities.

Excess steelmaking capacity of some 30 Mt and unrelenting competition from imported steel continued to plague the EEC. The response to these problems continued to be voluntary restraint agreements with many of its trading partners, quotas on imported steel, and production quotas in member states.

The EEC steel policy, specifically the European Commission's (EC) restructuring program, was due to expire December 31, 1987. However, many problems still remained and most member states, supported by their steel industries, were opposed to ending the quota system. Initially, the EC steel association, EUROFER, was tasked with the job of preparing a plan to reduce steelmaking capacity by 30 Mt/y as a prerequisite for obtaining an extension of the quota system. Although EUROFER was able to agree to a smaller reduction, this was not considered sufficient to deal with the oversupply problem. Faced with an impasse, the Commission again took the initiative and developed a co-ordinated approach. Its new restructuring proposal included a limited production quota system that would be in effect to the end of 1990 on hot rolled coils, thin cold rolled sheets, heavy plate and heavy sections. Based on this proposal, 20 Mt/y of excess capacity for products subject to quotas would be eliminated while 10 Mt/y would be rationalized through normal market mechanisms. The plan also called for measures to deal with the loss of 80 000 jobs resulting from the restructuring. The commission was explicit that the continuation of quotas would depend on industry commitments to proceed with restructuring and reserved the right to terminate the quota system if the industry's initial plans on restructuring, which were due by November 30, 1987, were inadequate. The commission also reserved the right to terminate the system if the rate of restructuring was insufficient by the summer of 1988. Industry's cost for the closures were to be born by the sale of production quotas between steel companies, plus a levy on production in excess of 70% of a company's production quota. The social and regional costs of the plan were to be partially covered by an EC contribution of some 750 million ECUS. Companies were also expected to bear some of the costs.

A major problem in obtaining approval of the Commission program was that the steel industry in some EEC countries had already been rationalized at their own expense and these countries objected to paying production levies to assist in the rationalization of their competitors.

On December 22, the EC Industry Council reached a decision that called for the removal of production quotas on wire rod and merchant bar on January 1, 1988, and the extension of production quotas on hot and cold rolled coil, heavy plate and heavy sections until June 30, 1988. There remained the possibility that production quotas could be extended if the Commission received undertakings to reduce capacity in the relevant categories.

A significant event in Europe included the announcement by the British government that British Steel Corp. (BSC) was to be privatized. The company had returned to profitability due to restructuring and reduced levels of employment. Employment was 52 000 at year-end 1987 compared to 200 000 ten years ago.

OUTLOOK

Canadian steel production in 1988 is forecasted to be very close to the level of 1987, about 14.5 Mt, and in 1989 somewhat less, 14.0 Mt. Sales of consumer durables, such as automobiles and appliances, are expected to decline in 1988. However, higher capital expenditures and additional commercial construction should make up the difference. For 1989, consumer spending will likely remain low while capital expenditures will decline to more average levels, a normal occurrence after some years of growth.

In terms of specific sectors, an anticipated recovery in exploration for oil and gas should increase the demand for oil country tubular products. Automobile production is forecasted to decline by 2% in 1988 and by a further 3% in 1989. Appliance sales are projected to decline slightly because new house construction is expected to decline, partially due to the financial losses that resulted from the stock market tumble in October 1987. Machinery and equipment sales might hold up well, in the short term, as many companies have operated profitably for the last three or four years and they are prepared to make capital investments to improve productivity, increase capacity and expand product lines. Commercial construction is holding at good levels in line with increases in capital expenditures, and pre-engineered steel buildings are expected to continue to be in strong demand.

In the medium term, 1990-92, consumer and capital expenditures are forecasted to increase, especially towards the end of that period.

In the longer term, domestic demand will rise and offshore imports of steel to Canada should decline as steel supply and demand are balanced throughout the world. Canadian steel production by the year 2000 is forecasted to increase by about 2 Mt to 16.5 Mt. Should a free trade agreement be implemented, production might expand further by about 1 Mt, but an increase in capacity would likely be required.

The extent of such medium and longer term growth, and even the base from which it is expected to occur, is difficult to forecast because of a number of economically significant occurrences that were in progress at the end of 1987. The latter are considered below.

Canada and the United States were in the process of negotiating a free trade agreement which, if implemented, would have a significant impact on the Canadian steel industry. Under free trade, the cost of consumer durables would probably decline slightly in the short term and available choice would increase, resulting in a slight increase in consumer demand and capital expenditures. Furthermore, free trade could result in slightly increased exports to the United States in the short term. Throughout 1987, most Canadian steel companies turned away a high percentage of the U.S. orders that they received to avoid aggravating protectionist sentiment in the United States. However, the Canadian steel industry does not expect free trade to result in a dramatic increase in the amount of steel shipped to the United States because of its need to supply rising domestic demand. In this regard, the Canadian industry has historically kept its capacity close to domestic demand and may have limited scope for meeting export markets. It should be remembered that as recently as 1980-81, steel users were restricted to quotas from mills for many steel products and that in 1987 there were shortages of some sheet products.

The implementation of free trade would increase capital expenditures significantly in the medium and longer term because many of Canada's secondary manufacturing companies are expected to increase capacity and invest in machinery and equipment to improve productivity. These investments would be a response in some cases to the opportunity to increase exports sales and in other cases for survival in the changed world of free trade. Many companies, which had not pushed for export sales in the past, would likely enter the U.S. market under free trade.

Another significant development was the abrupt drop in the value of the Canadian and U.S. dollar relative to other currencies in the last half of 1987. Should dollar values remain at current low levels for a significant time, specifically two or three years, the result would be positive for the North American steel industry because export sales would become possible at profitable levels, and imports of both steel mill products and steel intensive goods would likely decline. Both of the latter factors would foster increased sales of domestic steel.

Interest rates have a significant impact on the national economy and, therefore, on steel. During the first part of 1987, interest rates began to creep upwards and there was concern that inflation would return. High interest rates discourage both consumer and capital expenditures. During the last quarter, an abrupt decline in stock markets throughout the world occurred, and central banks in most countries responded by lowering the bank rate. Interest rates may be kept lower in the short term but, should stability return to the stockmarket, rates will likely begin to move upwards again.

Prices of Canadian steel mill products, which have been depressed for the past five years by the world surplus of steel, should increase slightly in the short and medium terms as the oversupply situation becomes less severe. In the longer term, domestic prices could increase significantly because of a shortage of some steel mill products.

TABLE 1. CANADA, GENERAL STATISTICS OF THE DOMESTIC PRIMARY IRON AND STEEL INDUSTRY, 1985-87

	1985	1986^{r}	1987P
		($ million)	
Production			
Gross Domestic Production at Factor Cost			
Manufacturing industries, 1981 dollars[1]	69 534.3	71 122.2	68 095.5
Primary steel industries, 1981 dollars[1]	2 208.5	2 183.6	2 161.1
Price			
INDEX Primary Steel Industries 1981=100	115.7	116.9	118.1^{e}
		($ million)	
Value of shipments, iron and steel mills[2]	7 695.7	7 947.9^{e}	..
Value of unfilled orders, year-end, iron and steel mills	877.6	994.8	..
Value of inventory owned, year-end, iron and steel mills	1 982.8	1 887.1	..
		(number)	
Employment, iron and steel mills[2]			
Administrative	11 703	11 268	1 200^{e}
Hourly rated	35 713	35 193	33 000
Total	47 438	46 461	44 200
		($)	
Average earnings per 40 hr week, hourly rated	647.20	683.23	700.00
		($ million)	
Expenditures, iron and steel mills (investment intentions in 1987)			
Capital: on construction	104.3^{r}	94.7	119.2
on machinery	335.1^{r}	691.6	897.4
Total	439.4^{r}	786.3	1 016.6
Repair: on construction	40.8^{r}	40.9	42.7
on machinery	725.2^{r}	745.8	768.5
Total	776.0^{r}	786.7	811.2
Total capital and repair	1 205.4	1 573.0	1 827.8
			(Jan.-Nov.)
Trade, primary iron and steel[3]			
Exports	2 191.2	2 407.1	2 439.0
Imports	1 843.4	1 842.0	1 876.5

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Reference numbers - I29005, I29357 and D614180. [2] S.I.C. Class 291 - Primary Steel Industries: covers the production of pig iron, steel ingots, steel castings, and primary rolled products, sheet, strip, plate, etc. This is a seasonally adjusted index. [3] Includes pig iron, steel ingots, steel castings, semis, hot and cold-rolled products, pipe, wire and forgings. Excludes sponge iron, iron castings.

P Preliminary; ^{r} Revised; ^{e} Estimated; .. Not available.

TABLE 2. CANADA, CRUDE STEEL PRODUCTION, SHIPMENTS, TRADE AND CONSUMPTION, 1985-87

	1985	1986[r]	1987[e]
		(tonnes)	
Furnace capacity, January 1[1]			
Steel ingot			
Basic open-hearth	1 907 200	1 907 200	1 000 000
Basic oxygen converter	11 779 000	11 279 000	11 279 000
Electric	5 586 450	5 586 450	5 563 450
Total	19 272 650	18 772 650	17 842 450
Steel castings	797 053	797 053	799 030
Total furnace capacity	20 069 703	19 569 703	18 641 480
Production			
Steel ingot			
Basic open-hearth)			
Basic oxygen)	10 553 639	9 939 033	10 300 000
Electric	3 978 349	4 048 539	4 300 000
Total	14 531 980	13 987 572	14 600 000
Continuously cast, included in total above	6 384 305	6 456 093	7 100 000
Steel castings[2]	105 500	93 833	115 000
Total steel production	14 697 480	14 081 405	14 715 000
Shipments from plants			
Steel castings	98 330	83 233	96 000
Rolled steel products	11 661 501	11 671 900	12 700 000
Total	11 759 831	11 755 133	12 796 000
		(000 tonnes)	(9 months)
Exports, equivalent steel ingots[3]	3 444.9[r]	3 749.5	3 081.6
Imports, equivalent steel ingots[3]	2 489.4[r]	2 443.5	1 989.4

Source: Statistics Canada.

[1] The capacity figures as of January 1 in each year take into account both new capacity and obsolete capacity anticipated for the year. [2] Produced mainly from electric furnaces. [3] Does not include fabricated steel product, steel forgings, pipe and wire.

[r] Revised; [e] Estimated.

TABLE 3. CANADA, PIG IRON PRODUCTION, SHIPMENTS, TRADE AND CONSUMPTION, 1985-87

	1985	1986[r]	1987
		(tonnes)	
Furnace capacity January 1[1]			
Blast	13 902 150	12 792 000	11 689 000
Electric	600 000	700 000	700 000
Total	13 170 000	13 492 000	12 389 000
			(Jan.-Sept.)
Production			
Basic	..	..	..
Foundry iron[2]	..	..	..
Total	9 665 427	9 248 530	7 373 707
Imports			
Tonnes	10 079	12 088	7 831
Value ($000)	3 510	3 433	2 693
Exports			
Tonnes	574 111	519 562	311 008
Value ($000)	131 528	115 346	76 473
Consumption of pig iron			
Steel furnaces[3]	9 792 015	9 285 247	7 393 972
Consumption of iron and steel scrap			
Steel furnaces	7 038 809	6 948 243	5 284 916

Sources: Statistics Canada; Primary Iron and Steel (monthly).

[1] The capacity figures as of January 1 in each year take into account both new capacity and obsolete capacity anticipated for the year. [2] Includes malleable iron. [3] Includes pre-reduced iron.

[r] Revised; .. Withheld to avoid disclosing company proprietary data.

TABLE 4. CANADA, VALUE[1] OF TRADE IN STEEL CASTINGS, INGOTS, ROLLED AND FABRICATED PRODUCTS, 1985-87

	Imports			Exports		
	1985[r]	1986[r]	1987[e] Jan.-Sept.	1985	1986[r]	1987[e] Jan.-Sept.
			($000)			
Steel castings	42 169	45 353	41 196	7 770	10 399	13 252
Steel forgings	20 864	27 499	18 660	81 910	70 921	40 761
Steel ingots	16 004	14 409	23 324	15 409	34 068	7 091
Rolled products						
Semis	32 817	71 380	94 170	17 185	36 346	20 754
Other	1 177 108	1 109 342	799 352	1 397 643[r]	1 467 179	1 271 434
Fabricated						
Pipe and tube	446 400	286 222	200 229	364 015	283 486	275 938
Wire	103 651	108 441	79 871	175 771[r]	194 013	135 746
Total steel	1 839 013	1 662 646	1 256 802	2 059 703[r]	2 096 430	1 764 976

Source: Statistics Canada.

[1] The values in this table correspond with the tonnages shown in Table 5.

[r] Revised; [e] Estimated.

TABLE 5. CANADA, TRADE IN STEEL BY PRODUCT[1], 1985-87

	Imports			Exports		
	1985r	1986r	1987e Jan.-Sept.	1985	1986r	1987e Jan.-Sept.
	(000 tonnes)					
1. Steel castings (including grinding balls)	27.3	33.9	41.9	3.8	4.5	7.2
2. Ingots	56.6	38.6	73.4	43.7	109.1	25.0
3. Semi-finished steel blooms, billets, slabs	88.0	216.0	336.9	33.0	124.3	55.5
4. Total (1+2+3)	172.0	288.6	452.9	80.5	237.9	87.7
5. Finished steel						
A) Hot-rolled						
Rails	67.5	72.3	37.9	97.0	101.4	138.9
Wire rods	223.2	285.8	187.4	322.2	360.8	297.4
Structurals	232.6	209.4	176.5	290.6	337.1	221.7
Bars	116.0	97.9	82.8	296.1	299.0	249.9
Track material	4.9	10.6	190.5	2.3	1.1	1.6
Plate	249.9	176.0	138.3	169.1	193.4	268.4
Sheet and strip	395.5	181.5	126.4	710.9	663.9	528.6
Total hot-rolled	1 289.7	1 034.5	768.4	1 888.3	1 956.7	1 688.5
B) Cold-rolled						
Bars	24.7	24.3	16.1	47.7	64.6	43.1
Sheet and strip	147.9	191.9	99.8	128.5	150.7	142.9
Galvanized	11.2	176.7	119.6	251.9	245.5	192.9
Other[1]	164.6	188.7	149.0	206.7	216.2	178.0
Total cold-rolled	448.4	581.7	384.5	634.9	677.0	556.9
6. Total finished steel (A+B)	1 738.1	616.2	1 152.9	2 523.2	2 633.7	2 245.4
7. Total rolled steel (2+3+6)	1 882.7	870.8	1 563.2	2 600.0	2 867.1	2 325.9
8. Total steel (4+6)	1 910.0	904.7	1 605.1	2 871.6	2 333.1	2 333.1
9. Total steel (raw steel equivalent)[2]	2 489.4	2 443.5	1 989.4	3 444.8	3 749.5	3 081.6
10. Fabricated steel products						
Steel forgings	6.6	6.5	5.4	37.6	33.0	19.3
Pipe	454.3	251.7	184.4	433.6	360.5	364.8
Wire	89.8	88.8	63.7	172.2	198.6	148.0
11. Total fabricated	505.7	347.0	253.5	643.4	592.0	532.1
12. Total castings, rolled steel and fabricated (8+11)	2 460.7	2 251.7	1 858.6	3 247.2	3 463.7	2 869.3

Source: Statistics Canada.

[1] Includes steel for porcelain enameling, terneplate, tinplate and silicon steel sheet and strip.

[2] Calculation: finished steel (row 6) divided by 0.75, plus steel castings, ingots and semis (row 4).

r Revised; e Estimated.

TABLE 6. PRICES FOR RAW MATERIALS AND SELECTED STEEL PRODUCTS, 1985-87[1]

	Currency	1985	1986	1987[e]
Raw Materials				
Iron ore pellets, Lake Erie base price, per metric iron unit[2]	US$	86.9	86.9	72.4
Coal, metallurgical, imported from United States for Ontario steel mills, per tonne f.o.b.[3]	US$[4]	56.9	55.2	49.6
Scrap, Number 1 heavy melting, per tonne Pittsburg U.S.A.	US$[4]	81.9	80.8	93.9
Direct reduced iron, per tonne	US$	115-135	115-135	115-135
Basic pig iron, per tonne	US$	213.00	213.00	213.0
Iron and steel scrap Price index 1981=100, D614305		100.7	100.1	103.6P

Sources: Statistics Canada; Skillings Mining Review; Iron Age; Energy, Mines and Resources Canada.

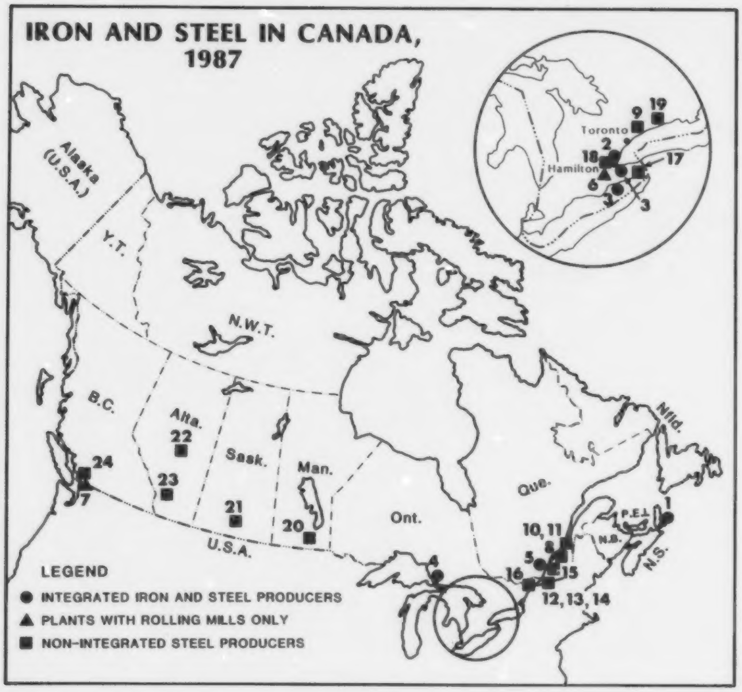
[1] Prices in effect at end of December of each year. [2] One iron unit equals one percent of a tonne. Hence, iron ore pellets with a grade of 65% iron would contain 65 iron units per tonne. [3] International Review weighted average. [4] Average.

P Preliminary; [e] Estimated; f.o.b. Free on board.

TABLE 7. WORLD RAW STEEL PRODUCTION, 1986 AND 1987

	1986^r	1987^e
	(million tonnes)	
U.S.S.R.	160.5	161.4
Japan	98.3	98.5
United States	73.8	81.3
People's Rep. of China	51.9	55.0
F.R. of Germany	37.1	36.7
Italy	22.9	22.7
Brazil	21.2	21.9
France	17.9	17.6
Poland	17.2	17.0
Czechoslovakia	15.1	15.3
United Kingdom	14.8	17.1
Republic of Korea	14.6	16.5
Romania	14.3	14.1
Spain	12.0	11.6
Canada	14.1	14.7
India	11.9	12.5
Belgium	9.7	9.7
DPR Korea	9.0	9.3
South Africa	9.1	8.9
East Germany	7.9	7.8
Mexico	7.2	7.3
Australia	6.7	6.1
Taiwan	5.5	5.6
Netherlands	5.3	5.1
Turkey	6.0	7.0
Austria	4.3	4.3
Sweden	4.7	4.5
Yugoslavia	4.5	4.4
Hungary	3.7	3.6
Venezuela	3.5	3.8
Luxembourg	3.7	3.3
Argentina	3.2	3.6
Finland	2.6	2.7
Bulgaria	2.8	2.7
Others	17.5	19.2
Total	714.5	732.7

Source: International Iron and Steel Institute.
Note: Totals may not add due to rounding.
^{e} Estimate; ^{r} Revised.


IRON AND STEEL IN CANADA, 1987
Alaska (U.S.A.)
Y.T.
N.W.T.
B.C.
Alta.
Sask.
Man.
Ont.
Que.
Nfld.
P.E.I.
N.B.
N.S.
U.S.A.
Toronto
Hamilton
1
2
3
4
5
6
7
8
9
10, 11
12, 13, 14
15
16
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20
21
22
23
24
LEGEND
● INTEGRATED IRON AND STEEL PRODUCERS
▲ PLANTS WITH ROLLING MILLS ONLY
■ NON-INTEGRATED STEEL PRODUCERS

Integrated iron and steel producers
(numbers refer to locations on map above)

1. Sydney Steel Corporation (Sydney)
2. Dofasco Inc. (Hamilton)
3. Stelco Inc. (Hamilton and Nanticoke)
4. The Algoma Steel Corporation, Limited (Sault Ste. Marie)
5. Sidbec-Dosco Inc. (Contrecoeur)

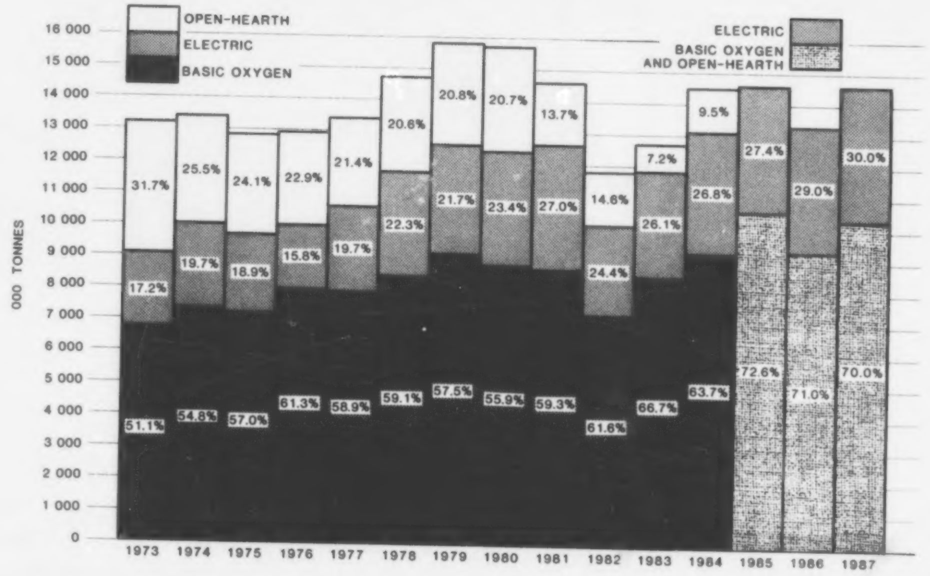
Plants with rolling mills only

6. Stanley Strip Steel division of Canada Inc. (Hamilton)
7. Pacific Continuous Steel Limited (Delta)

Non-integrated steel producers

8. QIT-Fer et Titane Inc. (Sorel)
9. Courtice Steel Limited (Cambridge)
10. Stelco Inc. (Contrecoeur)
11. Atlas Steels division of Rio Algom Limited (Tracy)
12. Sorel Forge division of Slater Industries Inc.
13. Canadian Steel Foundries, division of Hawker Siddeley Canada Inc. (Montreal)
14. Canadian Steel Wheel Limited (Montreal)
15. Sidbec-Dosco Inc. (Montreal and Longueuil)
16. Ivaco Inc. (L'Orignal)
17. Atlas Steels division of Rio Algom Limited (Welland)
18. Hamilton Specialty Bar division of Slater Industries Inc.
19. Co-Steel Inc. (Whitby)
20. Manitoba Rolling Mills division of the Canam Manac Group Inc.
21. IPSCO Inc. (Regina)
22. Stelco Inc. (Edmonton)
23. Western Canada Steel Limited (Calgary)
24. Western Canada Steel Limited (Vancouver)

CANADA, PRODUCTION OF STEEL BY FURNACE TYPE



Lead

A. BOURASSA

OVERVIEW

Non-socialist world consumption rose by less than 2% in 1987, but lead prices were strong during the year. Metal production increased faster at 3%, but labour management disputes, production difficulties and other disruptions added to concern about already low stock levels, created regional imbalances in supply and led to fears of tightness which pushed prices higher. The price of refined lead on the London Metals Exchange (LME) averaged US27¢/lb. in 1987 against 22¢ in 1986.

CANADIAN DEVELOPMENTS

Lead is mined principally as a coproduct of zinc in New Brunswick, British Columbia, the Northwest Territories and Yukon Territory. Smaller amounts are mined as a by-product of polymetallic ores in Ontario and Manitoba. Primary lead metallurgical works are located at Belledune, New Brunswick and Trail, British Columbia. Nominal capacities of these lead plants are 72 000 t/y and 136 000 t/y, respectively, but effective capacities depend on feed material and other factors. Eight secondary lead plants - those recycling lead-bearing scrap - have a combined capacity of 118 000 t/y and are located in Quebec, Ontario, Manitoba, Alberta and British Columbia.

In 1987, Canadian mines produced an estimated 414 000 t of lead in concentrates, about 65 000 t more than in 1986. Production of refined lead from all sources totalled about 217 000 t in 1987, down 41 000 t. Domestic consumption of refined lead as measured by producers' domestic shipments, is estimated at 87 000 t, down more than 15 000 t from 1986. Actual consumption could prove to be higher as the prolonged strike at Cominco Ltd. forced changes in regular supply patterns in North America.

A significant event for lead markets especially in North America, was the strike at Cominco Ltd. which closed the Kimberley mine and Trail complex from May 9 to the beginning of September. Resulting losses in refined lead production further tightened an already tight North American market, thus leading to steep price increases. The price differential between the North American producer price and the LME was consistently in excess of 10¢/lb. during the second half of the year.

In July, Pine Point Mines Limited ceased production at its mine in the Northwest Territories. Milling of the ore will continue into the early months of 1988 while shipments will continue well into 1989.

The modernization of the Trail lead smelter is now well under way and on schedule, with production expected to start in mid-1989. The first phase will cost $171 million.

Brunswick Mining and Smelting Corporation Limited is spending $7.2 million to expand the range of its products while reducing pollution. About $6 million will be spent on two short rotary furnaces and a cadmium leach plant. The furnaces will be used for the production of a lead-antimony alloy.

East-West Minerals NL acquired the Caribou property in New Brunswick from Anaconda Minerals Company. It is now developing the property and production could start in 1988. The mine will produce about 120 000 t/y of a bulk lead-zinc concentrate, containing about 29 000 t of lead. Most of the concentrate will be shipped to the AM&S Europe Ltd. smelter in Avonmouth, U.K. The lead grade of the orebody is 1.7% and the milling rate will be 2 000 t/d.

Lead capacity at the large Faro mine of Curragh Resources Corporation in the Yukon was increased by 27 500 t of lead to 110 000 t/y. Giant Resources Limited of Australia purchased a 46% interest in the

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Faro mine and Curragh Resources Corporation now holds a similar 46% share while Boliden AB owns the remaining 8%. Development work has started on the nearby Grum and Vangorda deposits. Production from these deposits will be gradually phased in as production from Faro declines.

The reader will find a list of all major Canadian nonferrous metal mines at the end of the commodity reviews.

Metallgesellschaft AG grouped together its foreign mining interests into a new company, Metall Mining Corporation, based in Canada. These assets include interests in Cominco Ltd., Teck Corporation; M.I.M. Holdings Limited of Australia and OK Tedi Mining Limited in Papua New Guinea.

The Canada-U.S. Free Trade Agreement should be a positive development for the Canadian lead industry. Removal of the low U.S. tariffs should improve profitability on U.S. sales. The industry does not however expect to significantly increase sales volume to the United States. Canadian lead metal exporters already have the largest share of U.S. metal imports. There is also the possibility that sales of Canadian made alloys and powders to the U.S. could be facilitated in some geographical areas and product sectors.

The Canadian lead mining industry is generally considered very cost competitive internationally. In Canada, lead is a by-product of zinc mining and most deposits also contain recoverable amounts of silver. Other deposits also include copper and gold. The polymetallic nature of Canadian deposits reduces the vulnerability of the producers to the price fluctuations of each individual commodity. Additionally, Canadian mines have generally good grades and are large, well equipped and managed with the benefit of a productive labour force.

The lead smelting industry, on the other hand, still relies on obsolete technology characterized by high energy costs, limited flexibility and fugitive emissions. The low Canadian dollar and satisfactory lead prices have allowed the smelters to be profitable. Cominco is now in the process of building a new smelter which by 1989 will be one of the most modern and competitive in the world. Brunswick Mining and Smelting is also investigating alternative smelting technologies for use in the possible modernization of its lead smelter.

WORLD DEVELOPMENTS

In Australia the Cadjebut mine owned by BHP Minerals Ltd. (58%) and Billiton Australia (42%) produced its first ore. It should produce 8 000 t/y of lead in concentrate in 1988 in addition to zinc concentrate. Reserves are estimated at 3.3 Mt. The Woodlawn mine was sold by CRA Limited to Denehurst Ltd. Open pit operations have been terminated but mining has now started underground. Production is expected to be about 10 000 t/y of lead in concentrate. The Hellyer mine owned by Aberfoyle Limited, started production in 1987 at 12 000 t/y of lead. A study is now under way to assess expansion of production to about 50 000 t/y.

In Brazil, Paulista de Metais Ltda. is planning to raise lead output from 32 000 to 40 000 t/y after acquiring the Boquira and Plumbum operations from Société minière et métallurgique de Penarroya S.A. (Penarroya) earlier in 1987 at a cost of US$18 million. The operation is now called the Sociedad Paulista de Metais.

After several delays due to postponements of equipment deliveries, the Morro Agudo mine in Brazil finally opened in December. Capacity is 6 500 t/y of lead. The mine is owned by Mineracao Morro Agudo S.A.

In Germany, Preussag AG announced that it will close its Rammelsberg and Grund lead-zinc mines in 1988. Combined lead production was about 18 000 t/y of lead. The Bindsfeldhammer primary lead smelter, owned and operated by Berzelius Metallhütten GmbH, a subsidiary of Metallgesellschaft, will be upgraded using the Q.S.L. process at a cost of DM 90 million. Production will remain unchanged at 80 000 t/y.

In Honduras, American Pacific Holdings (APH) of Greenwich, Connecticut took over the El Mochito mine from an AMAX Inc. subsidiary, Rosario Resources Corporation. The company is now negotiating special concessions from the government in order to reduce costs and return the mine to profitability.

India will receive $25 million in assistance from the U.K. government to finance the Rampura Agucha mine and the Chanderiya smelter in Rajasthan. The mine will produce 8 000 t/y of lead in concentrate and the smelter 35 000 t/y of lead.

Four mines, the Akenobe, Hosokura, Nakatatsu and Shakanai, were closed in Japan in 1987, for a combined loss of about 15 000 t/y of lead. A new mine, the Nurukawa mine of Uchinotai Mining Co., was opened in April 1987. It will produce under 2 000 t/y of lead.

In Spain, Cia Industrial Asua Erandio S.A. (Aser) made its first shipment of Waelz briquettes from its new plant in northern Spain. The briquettes contain about 15% lead. Sales have been made to AM&S in the United Kingdom and Nuova Samin in Italy. Boliden bought Andaluza de Piritas S.A. (Apirsa), which operates the Aznacollar open pit mine. It produced 19 400 t of lead in 1986.

In Sweden, Boliden AB announced plans to invest up to US$480 million on a domestic mine expansion program. The objective of the program is to assure a long term and secure source of feed for the Ronnskar copper and lead smelting complex. Boliden now operates 16 mines in Sweden, producing a total of 84 000 t/y of lead. Lead production at Ronnskar totals 59 000 t/y. The program would include about 20 projects including the expansion of the Laisval mine which produces about 60 000 t/y of lead. Boliden has asked the Swedish government to fund 35% of the program. In December the government offered $12.8 million and Boliden warned that drastic measures may have to be taken as a result. Boliden is now wholly-owned by Trelleborg AB.

In the United States, Cominco Alaska Incorporated decided to proceed with development of the Red Dog lead-zinc deposit in Alaska. Construction of a road to the site has started and Ralph M. Parsons Company has been awarded the design and procurement for the modular lead and zinc concentrator. The plant will mostly be built outside Alaska and shipped in modules during the summer of 1989. Production will start in 1990 and will reach 64 000 t/y of lead. ASARCO Incorporated will reopen the Sweetwater (formerly Milliken) lead mine in Missouri on a limited basis, with production set at about 10 000 t/y. The ore will be smelted at the company's Glover smelter. Hecla Mining Company's Lucky Friday silver/lead mine in Idaho was reopened in June and production is expected to reach 20 000 t/y in 1988. The Greens Creek project in Alaska is going ahead with production to start in mid-1988 at 9 000 t/y of lead. Reserves are estimated at 3.2 Mt grading 3.9% lead and 9.7% zinc. Greens Creek Mining Co. is a wholly owned subsidiary of Amselco Minerals Inc., part of the BP Minerals International Ltd. group.

On October 22, Dunlop Holdings Inc. bought 60% of GNB Inc. whose assets include a battery division and two secondary lead smelters in the United States. Dunlop will acquire the remaining 40% over time. Dunlop will now be the largest battery producer in the world. The new amalgamated company, called Pacific Dunlop-GNB Inc., will have a smelting capacity estimated at 115 000 t/y. Under new environmental regulations on hazardous waste exports implemented by the United States Environmental Protection Administration (EPA), foreign governments must now confirm in writing their consent to import scrap lead batteries from the United States before the export sale will be allowed to proceed. EPA has also proposed a new Toxic Characteristic Leaching Process test that could create problems for several secondary smelters. This test would replace the Extraction Procedure test. Slag that fails the new test would have to be disposed of in specially regulated toxic waste landfills, significantly adding to disposal costs. A decision on the new test is expected in 1988. EPA has now advised scrap suppliers to the now closed Bergsoe plant in St. Helens, Oregon, that they may be liable for clean-up costs at the site. The company is now bankrupt and cannot pay the cleanup costs.

INTERNATIONAL INSTITUTIONS

International Lead Zinc Study Group

The International Lead and Zinc Study Group was formed in 1959 to provide opportunities for regular intergovernmental consultations on international trade in lead and zinc, to make such special studies of the world situation in lead and zinc as may be appropriate and to consider possible solutions to any special problems or difficulties which are unlikely to be resolved in the ordinary development of world trade. Particular attention is given to providing continuous information on the supply and demand position and its probable development.

It is now headquartered in London, England. The membership of the Group includes most major lead and zinc producing and consuming countries. While it has an extensive information gathering and dissemination role, the Group has no market intervention powers. It holds a general session each year in the fall. Member countries' delegations generally include industry representatives as advisors. It is noteworthy that China joined the organization in 1987, as did Turkey and the Republic of Korea. It is the first time that China has joined an international commodity organization. Canada has been an active member since its inception.

STOCKS

LME stocks of lead metal stood at 37 600 t at the beginning of 1987, but had fallen to 10 275 t by mid-May, probably a result of stocking by consumers fearing a tight market because of the Cominco strike and the possibility of a strike at Brunswick in midsummer. Stocks rebounded to 28 700 t in mid-August but then fell to remain below 20 000 t for most of the last quarter. At time of writing, International Lead Zinc Study Group (ILZSG) data on producers and consumers stocks were not available. However, preliminary data indicates that total reported metal stocks at the end of the year, including producers stocks, were more or less the same as at the beginning of the year.

PRICES

Differing market conditions between North America and the rest of the world were clearly reflected by price levels and differentials. On the LME, lead prices reached a low of US20¢/lb. in January and a high of 34.5¢ in May after the beginning of the strike at Cominco. The average price for 1987 was US27¢/lb. The U.S. producer price reached a low of US25¢/lb. in April but increased rapidly thereafter. It remained at 42¢/lb. in the latter half of the year. A 3¢-4¢/lb. price differential between the LME and North America producer price has been the norm in the past. Except for March, April and May, the price differential was much wider in 1987, being well over 10¢ in the latter part of the year and reaching as high as 15¢. Such an extensive differential reflected the extremely tight supply situation in North America. In fact, some North American producers made substantial purchases on the LME in order to meet their sales commitments. Over 30 000 t are estimated to have been purchased in this way. Low stock levels on the LME, especially in the major warehouses in Rotterdam and Antwerp, plus scarcity of the higher quality metal required by North American consumers, made it more costly to arrange major shipments of metal from Europe, thereby raising the price differential.

USES

Lead's malleability allows it to be rolled to thicknesses down to 0.01 mm for use in gaskets, washers, impact extrusion blanks, soundproofing, radiation protection and architectural applications. Lead can also be extruded in the form of pipe, rod, wire or other cross-sections and around power cables. Flux-cored, tin-lead solders and cable sheathing are typical extrusions. The low melting point of lead allows the simple casting of counterweights, sailboat keels and minute diecastings for instruments. Type metal is noted for its ability to reproduce fine detail. Storage battery grids may be either cast or rolled and expanded. Grids, together with battery posts and battery oxides, represent the largest uses for lead, about 60%. Lead shot is used in ammunition and for weights or sound and radiation shielding where accessibility is a problem. Lead and lead alloy powder and flakes are added to pipe joint compounds, powder metallurgy products (such as bearings, brake linings and clutch facings) and solder pastes, and are incorporated into rubber and plastics for soundproofing curtains.

Calcium, antimony, tin or arsenic is generally added to impart castability, strength or hardness to lead alloys. When added to steel, brass or bronze, lead improves machineability. Alloyed with tin, lead is used as a hot-dip coating alloy to produce terne-coated steel. Lead oxides and other compounds are used in paints, pigments, glazes and a wide variety of chemicals. Tetraethyl lead - a gasoline additive - continues to decline in importance but still represents a significant market, particularly for primary refined lead. New uses and existing ones are being evaluated by the International Lead and Zinc Research Organization. Nuclear wastes are generated at about 15 300 t/y and this is expected to grow. One existing nuclear material container design would require 5.25 t of lead for each t of waste. Corrosion characteristics of lead and lead alloys in various environments are being tested for this application. Several projects are under way to optimize the performance of shallow-discharge (starting-lighting-ignition type) and deep-discharge (traction type) lead-acid batteries, and to investigate glass-mat separations to prevent acid spillage.

Testing of load-levelling batteries for large users and producers of electricity may lead to a large potential market - perhaps 1 to 5 Mt worldwide in the long-term. Tests on a 400-kWh, lead-acid load-levelling battery will begin in 1987 at Chino, California. By discharging during peak consumption and recharging during off-peak hours, a load-levelling battery could reduce the need to install excess generating capacity.

The Lead Industries Association, Inc. continued its longer term efforts to improve existing markets for lead and to find new high growth areas. The LIA plans to actively participate in the effort of the Electric Power Research Institute (California), the International Lead and Zinc Research Organization (New York) and major electric utility and engineering firms in the development of the load levelling battery market, including the Chino tests noted above. LIA also plans to further define market potential for uninterruptible power supply systems, automatic guided vehicle systems, electric golf carts and lead solder, and to further promote lead use in asphalt and PVC plastic stabilizers and roofing components. Public awareness campaigns on environmental health are another major part of LIA activities.

OUTLOOK

Short-term

Western world mine production is expected to increase only slightly in 1988, by less than 1%. Canadian production should drop by about 50 000 t following the closure of the Pine Point mine. U.S. production, on the other hand, is expected to grow again after a period of cut-backs and rationalization over the last few years.

Western world metal production is projected to increase by 2% to about 4 255 000 t in 1988. Canadian metal production in 1988 should be back to normal levels of about 250 000 t, assuming no major disruptions. Western world consumption is forecast to rise by about 1.5%. Assuming that exports to socialist countries remain at the same levels as in 1987, this should leave a slightly positive statistical balance. This should allow the rebuilding of stocks to somewhat more normal levels but lead prices may consequently decline as the year progresses. Nevertheless, the LME price in 1988 is expected to average about US25-26¢/lb. Higher than usual price differentials between the LME settlement price and the North America price are expected to continue at least until the summer.

Long-term

Canadian lead mining capacity is expected to drop progressively to the end of this century. Some major lead-bearing deposits will become exhausted (Pine Point, Sullivan) or could be producing ore with lower lead content (Brunswick, Polaris, Faro). At this time, there appears to be no major deposits with large lead content on the horizon to fully compensate for the losses. The total loss could exceed 100 000 t. No change is expected in smelting and refining capacity over the same period.

Australia and the United States, on the other hand, should increase their lead mine production. The Red Dog deposit will be the main factor in increased U.S. production.

Lead consumption is hard to predict over a long period. As more and more of lead consumption rests on one use - batteries - total consumption has the potential for more volatility. A breakthrough in load levelling for utilities could bring substantial increases in lead consumption while a successful challenge to the lead auto battery later in the next decade could be quite damaging. If lead can maintain its monopoly in car batteries, total consumption will increase but very slowly because of losses in other lead uses.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
CANADA					
32900-1	Ores of lead	free	free	free	free
33700-1	Lead, old scrap, pig and block	free	free	1¢/lb.	free
33800-1	Lead in bars and in sheets	4.0	4.0	25	2.5
33900-1	Manufactures of lead, not otherwise provided for	10.2	10.2	30	free
UNITED STATES (MFN)					
602.10	Lead bearing ores per lb. of lead content		0.75¢		
624.02	Lead bullion (lead content)		3.5		
624.03	Other unwrought unalloyed lead		3.0% but not less than 1.0625¢/lb. to December 31, 1988		
624.04	Lead waste and scrap (lead content)		2.3		

EUROPEAN ECONOMIC COMMUNITY: (MFN)		1987	Base Rate	Concession Rate
26.01	Lead ores and concentrates	free	free	free
78.01	Lead unwrought	3.5	3.5	3.5
	Lead waste and scrap	free	free	free
JAPAN (MFN)				
26.01	Lead ores and concentrates	free	free	free
78.01	Lead unwrought			
	Unalloyed	6.0	7.5	6.0
	Alloyed	6.5	12.0	6.5
	Other	4.7	7.0	4.7
	Lead waste and scrap	3.2	5.0	3.2

Sources: The Customs Tariff, 1987, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1987), USITC Publication 1910; U.S. Federal Register Vol. 44, No. 241; Official Journal of the European Communities, Vol. 29, No. L 345, 1986; Customs Tariff Schedules of Japan, 1987.

TABLE 1. CANADA, LEAD PRODUCTION AND TRADE 1985-87 AND CONSUMPTION 1984-86

	1985		1986		1987P	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Production						
All forms[1]						
British Columbia	116 811	67 418	91 947	62 607	67 210	71 041
New Brunswick	68 375	39 462	66 590	45 341	79 433	83 960
Northwest Territories	77 083	44 488	133 836	91 129	134 499	142 166
Yukon	1 470	848	35 091	23 893	100 267	105 982
Ontario	3 812	2 200	6 287	4 281	8 500	8 984
Manitoba	740	427	590	401	594	628
Newfoundland	-	-	-	-		
Total	268 292	154 845	334 342	227 653	390 503	412 762
Mine output[2]	284 595	..	349 281	..	414 088	..
Refined production[3]	173 220	..	169 934	..	139 479	
Exports					(Jan.-Sept.)	
Lead contained in ores and concentrates						
Belgium-Luxembourg	11 534	2 043	16 400	3 417	13 625	4 580
France	1 981	400	2 122	458	2 202	746
Italy	5 356	1 035	11 452	2 878	8 365	4 070
Spain	-	-	2 364	683	0	0
West Germany	19 987	3 294	7 511	1 891	11 842	4 359
United Kingdom	3 310	653	4 039	845	3 607	1 131
United States	11 155	3 899	6 368	2 071	8 195	3 755
Japan	40 334	10 474	53 749	15 185	29 330	99 768
Other	0	0	8 911	1 939	16 491	3 870
Total	93 657	21 802	112 916	29 369	91 718	32 488
Lead and alloy scrap, dross, etc. (gross weight)						
Belgium-Luxembourg	892	302	-	-	0	0
Netherlands	2 385	693	1 018	526	0	0
Spain	204	45	-	-	0	0
United Kingdom	767	436	915	555	771	250
West Germany	505	135	3 743	965	1 052	229
United States	2 116	1 010	2 987	895	3 079	1 545
Brasil	3 439	1 070	10 497	2 287	7 054	1 874
Korea, Republic of	447	76	0	0	531	180
Taiwan	168	29	4 284	648	114	53
Other	264	36	2 012	455	172	46
Total	11 222	3 840	25 456	6 331	12 773	4 077
Lead pigs, blocks and shot						
Belgium-Luxembourg	4 994	2 826	1 237	676	4 924	4 495
Italy	302	193	3 268	1 951	4 708	4 055
West Germany	1 095	483	1 002	641	2 004	1 632
United Kingdom	28 300	12 851	20 980	10 009	13 491	8 855
United States	73 954	37 811	82 524	49 136	45 215	37 589
U.S.S.R.	773	431	0	0	0	0
People's Republic of China	-	-	1 000	448	0	0
Other	4 575	2 469	1 720	786	0	0
Total	113 993	57 064	111 831	63 729	72 213	57 835
Lead fabricated materials n.e.s.						
United States	14 516	9 021	18 241	12 054	11 810	10 577
Other	1 506	1 284	4 722	2 903	3 109	2 324
Total	16 022	10 305	22 963	14 957	14 919	12 901
Imports						
Lead pigs, blocks and shot	5 675	3 433	4 247	2 750	7 774	7 030
Lead oxide, dioxide and tetroxide (gross weight)	2 069	1 920	2 151	2 223	3 738	4 400
Lead fabricated materials n.e.s.	513	893	932	1 389	1 210	2 131
Lead in crude ores	295	90	38	3	-	-
Lead in dross, skimmings and sludge (gross weight)	-	-	35	7	221	138
Lead and lead alloy scrap (gross weight)	44 308	5 884	61 530	7 702	55 167	9 806

TABLE 1. (cont'd)

	1984			1985			1986P		
	Primary	Secondary[5]	Total	Primary	Secondary[5]	Total	Primary	Secondary[5]	Total
Consumption[4]									
Lead used for, or in the production of:									
Antimonial lead	4 813	x	x	3 452	x	x	2 960	x	x
Batteries and battery oxides	35 228	5 208	40 326	34 627	7 767	42 394	26 831	11 240	38 071
Chemical uses; white lead, red lead, litharge, tetraethyl lead, etc.	15 651	4 572	20 223	14 395	3 065	17 460	9 653	x	x
Copper alloys; brass, bronze, etc.	187	102	289	278	123	401	414	72	486
Lead alloys:									
solders	1 527	11 494	13 021	1 197	6 085	7 282	1 382	2 017	3 399
others (including babbitt, type metals, etc.)	61	296	357	421	2 482	2 903	553	2 729	3 282
Semi-finished products: pipe, sheet, traps, bends, blocks for caulking, ammunition etc.	4 815	x	x	4 483	x	x	1 112	x	x
Other lead products	3 328	x	x	3 134	x	x	5 222	2 005	7 227
Total, all categories	65 610	46 032	116 642	61 987	39 520	101 507	48 127	31 485	79 612

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Lead content of base bullion produced from domestic primary materials (concentrates, slags, residues, etc.) plus estimated recoverable lead in domestic ores and concentrates exported. [2] Lead content of domestic ores and concentrates produced. [3] Primary refined lead from all sources. [4] Available data, as reported by consumers. [5] Includes all remelt scrap lead used to make antimonial lead.

P Preliminary; - Nil; .. Not available; n.e.s. Not elsewhere specified; x Confidential, but included in "other".

TABLE 2. CANADA, LEAD PRODUCTION, TRADE AND CONSUMPTION, 1970, 1975, 1981-87

	Production		Exports				
	All forms[1]	Refined[2]	In ores and concentrates	Refined	Total	Imports Refined[3]	Consumption[4]
				(tonnes)			
1970	353 063	135 637	186 219	138 637	324 856	1 995	85 360
1975	349 133	171 516	211 909	110 882	322 791	1 962	89 192
1981	268 556	168 450	146 307	119 816	266 123	9 220	110 931
1982	272 187	174 310	106 744	146 130	252 874	5 661	103 056
1983	271 961	178 043	85 459	147 263	232 722	2 550	88 579
1984	264 301	174 987	114 720	124 149	238 869	6 313	111 642r
1985	284 595	173 220	93 657	113 993	207 650	5 675	101 507r
1986	334 342	169 934	112 916	111 831	224 747	4 247	79 612
1987P	390 503	139 479	91 718[5]	72 213[5]	163 931[5]	7 774[5]	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Lead content of base bullion produced from domestic primary materials (concentrates, slags, residues, etc.) plus the estimated recoverable lead in domestic ores and concentrates exported. [2] Primary refined lead from all sources. [3] Lead in pigs and blocks. [4] Consumption of lead, primary and secondary in origin as measured by survey of consumers except for 1986 estimate. [5] January to September 1987.
P Preliminary; r Revised; .. Not available.

TABLE 3. CANADA, PRIMARY REFINED LEAD CAPACITY, 1987

Company and Location	Nominal Annual Capacity
	(tonnes of refined lead)
Brunswick Mining and Smelting Corporation Limited Belledune, New Brunswick	72 000
Cominco Ltd. Trail, British Columbia	136 000
Canada total	208 000

TABLE 4. NON-SOCIALIST WORLD REFINED LEAD PRODUCTION[1], 1985-87

	1985	1986	1987e
		(tonnes)	
North America	1 287	1 174	1 237
Central and South America	421	397	400
Europe	1 608	1 606	1 612
Africa	159	144	146
Asia	537	572	560
Oceania	220	175	217
Total	4 232	4 068	4 172

Source: International Lead and Zinc Study Group, EMR estimates.
[1] From all sources but excluding lead from secondary materials treated by remelting alone.
e Estimated.

TABLE 5. NON-SOCIALIST WORLD REFINED LEAD CONSUMPTION[1], 1985-87

	1985	1986	1987[e]
		(000 t)	
North America	1 221	1 224	1 240
Central and South America	287	277	281
Europe	1 609	1 645	1 625
Africa	121	117	117
Asia	733	760	759
Oceania	69	68	68
Total	4 040	4 091	4 090

Source: International Lead and Zinc Study Group, EMR estimates.

[1] Total consumption of refined pig lead, including the lead content of antimonial lead.

[e] Estimated.

TABLE 6. PRINCIPAL USES OF LEAD, MAJOR CONSUMERS, 1987[e]

Uses	Europe	United States	Japan
	(per cent of total demand)		
Batteries	45	76	68
Cable Sheathing	5	2	2
Pipe and Sheet	21	3	4
Chemicals[1]	20	9	16
Alloys	4	4	5
Other	5	6	5

[1] Including tetraethyl lead.

[e] Estimated, totals may not add to 100% due to rounding.

TABLE 7. NON-SOCIALIST WORLD MINE PRODUCTION, 1985-87

	1985	1986	1987[e]
		(000 t)	
North America	709	701	744
Central and South America	466	456	456
Europe	411	410	397
Africa	260	229	213
Asia	152	169	148
Oceania	474	418	443
Total	2 472	2 393	2 401

Source: International Lead and Zinc Study Group, EMR estimates.

[e] Estimated.

TABLE 8. MONTHLY AVERAGE LEAD PRICES, 1986 and 1987

	United States Producer[1]	Canadian Producer	LME Settlement
	(US¢/lb.)	(C¢/lb.)	(£/t)
1986			
January	18.4	25.9	259
February	17.8	25.5	257
March	18.2	26.6	250
April	18.7	26.2	247
May	19.4	26.6	248
June	22.1	31.3	277
July	21.9	33.0	252
August	22.4	33.0	264
September	23.4	32.4	277
October	25.6	35.0	305
November	28.0	36.0	332
December	28.7	40.0	360
Year Average	22.0[2]	30.9	277
1987			
January	27.88	38.3	308
February	26.04	34.5	301
March	26.00	34.5	306
April	27.85	36.9	341
May	34.95	47.4	416
June	36.93	49.7	386
July	41.67	55.8	412
August	42.00	55.8	412
September	42.00	55.8	393
October	42.00	55.8	361
November	42.00	55.8	362
December	42.00	55.8	360
Year Average	35.94	48.0	363

Source: Metals Week, Northern Miner.

[1] North American Producer Mean from October 1986. [2] Unofficial average, official average not available.

Magnesium

G. BOKOVAY

Western world consumption of magnesium metal in 1987 is estimated to have increased by about 2.8% to 232 000 t. Assuming no major downturn in the major non-socialist economies and continued strength in prices for competing aluminum, the short-term outlook for the magnesium industry is quite positive.

With one new magnesium project already under way, another expected to begin shortly and a major expansion to an existing plant in progress, Canada is poised to become a major player in the world magnesium industry during the next decade. While this major increase in capacity will result in a much more competitive environment - an environment which may force certain existing producers out of business - it is expected that lower magnesium prices will stimulate increased magnesium usage and ultimately strengthen the industry as a whole.

CANADIAN DEVELOPMENTS

Timminco Metals, a division of Timminco Limited, is currently Canada's only producer of primary magnesium. The company operates a plant at Haley, Ontario, about 110 km west of Ottawa. Timminco uses the Pigeon magnesium process in which calcined dolomite is reduced by ferrosilicon in a vacuum retort. The ferrosilicon used in the process is produced by the company at Beauharnois, Quebec, while the dolomite is mined at the plant site. Although the capacity of individual vacuum retorts is quite low and the cost of their maintenance is quite high, the process is energy efficient and the output is of extremely high purity.

During 1987, Timminco Limited continued with its expansion and modernization of magnesium production facilities at its Haley plant. The project, which will boost magnesium capacity 50% to about 15 000 t/y, will take four years to complete and cost $23.3 million. Aside from technical improvements at the facility, additional capacity will be gained by moving strontium and calcium production from Haley to a new plant at nearby Westmeath, Ontario.

In the spring of 1987, Norsk Hydro AS began construction of its new 60 000 t/y magnesium plant at Bécancour, Quebec. The plant, which is expected to commence production during the first half of 1989, will employ about 350 permanent workers. While construction at year-end was on schedule, the company reported that it was experiencing a cost over-run of between 20 and 30%. The budgeted cost for the project was 2 billion kroner (about $410 million at current exchange rates).

In November, Norsk announced that it had decided against the construction of a plant in Quebec to supply feedstock to the new magnesium smelter because it would be more cost effective to purchase required inputs on the open market.

Also in Quebec, Noranda Minerals Inc. and Lavalin Inc. are proceeding with a prefeasibility study on the recovery of magnesium from asbestos tailings in the Thetford Mines region. It is expected that the study will be completed by the spring of 1988, at which time a decision will be made on a full feasibility study.

In Alberta, MPLC Holdings S.A. and Alberta Natural Gas Company Ltd. announced in July the formation of a joint venture to construct and operate a new primary magnesium plant at Aldersyle, near High River. The 62 500 t/y plant, which will be operated under the name Magnesium Company of Canada Ltd. (Mag Can), is expected to cost $370 million. The Government of Alberta has agreed to provide $265 million in loan guarantees for the project. The first phase of the new plant, consisting of 12 500 t/y of capacity, is scheduled to begin production in August 1989.

The Aldersyde facility will utilize the new MPLC process which is claimed by its

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backers to represent a major breakthrough in magnesium production technology. The heart of the process is a single step reactor which converts magnesite ore directly to molten anhydrous magnesium chloride, the basic raw material required for electrolytic reduction to primary metal. The process is reported to consume 15% less power than is required for the production of aluminum. While Mag Can will presumably obtain its magnesite from the deposit of Baymag Mines Co Limited near Radium Hot Springs in British Columbia, there has been no official confirmation in this regard.

A similar Alberta development involving MPLC was announced during 1986. However, this particular project was shelved later in the same year following the withdrawal of the Aluminum Company of America (Alcoa) from the venture owing to a change in corporate direction.

Also during 1987, it was reported that an improved silicothermic process for the production of metallic magnesium was patented by Dr. J.R. Wynnyckyj from the University of Waterloo. The new process utilizes a packed bed gas/solid reactor that can operate at normal atmospheric pressure. Unlike similar exising techniques, this process is fully continuous.

WORLD DEVELOPMENTS

The International Magnesium Association (IMA) reported that for the first nine months of 1987, shipments of primary magnesium in the western world were 174 900 t compared with 169 600 t during the same period in 1986. The IMA also reported that western world production for the first nine months of 1986 totalled 171 900 t compared with 168 600 t for the similar period in 1986. On September 30, magnesium inventories were reported to be 40 900 t, compared with 46 000 t a year earlier.

The United States, which is the largest magnesium producer in the world, has three primary magnesium plants. The Dow Chemical Company, the largest U.S. producer, operates an 86 000 t/y electrolytic magnesium plant at Freeport, Texas. The magnesium chloride feedstock for the plant is derived from a seawater/dolomite process. After operating at a rate of about 70 000 t/y through the first half of 1987, the company announced that it would increase production effective November 1. The extent of the increase was not announced. As a result of a modernization program undertaken by Dow at its Freeport operations during the 1970s, the company claims to have reduced energy consumption by 38% to 56 000 Btu/lb. - the lowest in the industry. In addition, Dow reported that worker productivity at Freeport had doubled since 1982.

AMAX Magnesium Corporation operates a primary magnesium plant at Rowley, Utah. This plant, which utilizes an electrolytic process, has a capacity of about 34 500 t/y. Magnesium chloride feedstock is normally derived from natural brines of the Great Salt Lake. However, high water levels on the lake in 1986 severely damaged the company's solar ponding system and disrupted raw material supplies. Although the magnesium plant continued to operate with purchased brines, production dropped to about 25 000 t in 1986 and was expected to remain about the same in 1987. In July, AMAX announced that it would build a new system of solar evaporation ponds at a cost of about US$20 million. The new ponds will be built in a shallow depression in Utah's West Desert into which the State of Utah is pumping water from the Great Salt Lake in an effort to halt rising lake levels. It is expected the evaporation system will be completed by 1988 although brine yields will not reach design capacity until 1989.

Northwest Alloys, Inc. a subsidiary of the Aluminum Company of America (Alcoa), operates a plant at Addy, Washington, that uses the Magnatherm process in which magnesium is produced by reducing dolomite with ferrosilicon. Capacity is about 36 000 t/y although it was reported in August that the operation was achieving a rate of production somewhat in excess of that level.

Norsk Hydro, the second largest non-socialist magnesium producer, operates a primary magnesium plant at Porsgrunn, Norway. The plant produces magnesium by the electrolysis of magnesium chloride derived from both a seawater/dolomite process and magnesium chloride brines imported from West Germany. With the completion of a modernization program at the Porsgrunn plant in 1984, magnesium metal capacity is now about 60 000 t/y. Although the company had considered increasing capacity at this facility, it announced at the beginning of 1987 that it would not undertake an expansion in the forseable future.

In Brasil, Companhia Brasileira de Magnesio (Brasmag), now controlled by Rima Eletrometalurgia S/A, was forced to modify its previously announced expansion plans due to electric power shortages and to problems experienced in procuring equipment. The most recent plans are for a doubling of existing capacity to 12 000 t/y over the next year and an increase to 36 000 t/y by 1992.

During 1986, Elkem A/S in cooperation with other Norwegian interests and the Brasilian producer, Brasmag, announced plans for a new 15 000 t/y magnesium plant to be built at Sauda in Norway. Although a final decision has been delayed, the project is reported to be still under consideration.

Elsewhere in the world it was reported that Tamil Nadu Chemical Products of India was scheduled to bring a new 600 t/y magnesium plant on stream in September 1987. This plant is somewhat unique in that it will use sea bittern (the residual brine in saltworks) as its raw material. In Japan, it has been reported that Japan Metals & Chemicals Co. Ltd. (JMC) will begin production of magnesium metal in June 1988. JMC's plant, which is located at Nomachi, in western Honshu, will utilize the Magnatherm process. Capacity of this operation is expected to be about 3000 t/y.

During 1987, it was also reported that Queensland Metal Corp. of Australia was considering the construction of a new 30 000 t/y magnesium production facility while in Saudi Arabia, a feasibility study for a primary metal plant is under way.

PRICES

During 1987, the list price for magnesium ingot (99.8% purity metal in 10 000 pound lots, delivered) was steady at US$1.53/lb. The price of magnesium diecasting alloy was quoted at $1.29-$1.33/lb.

Since the specific gravity of magnesium is only two thirds that of aluminum, magnesium remains competitive on a volume basis as long as its price does not exceed 1.5 times the price of aluminum. With the price of secondary "380" aluminum diecasting alloy reported to be about US85¢/lb. at the end of 1987, the two metals are quite competitively priced.

At the end of 1987, Dow announced price increases of US5¢/lb. for primary magnesium, desulphurizing grade magnesium and various sand casting alloys. However, the increase will only apply to "off-schedule" prices, which were reported during 1987 to be as much as 10¢/lb. below listed prices. The net result of this announcement will be that transaction prices will move closer to posted price lists.

USES

The largest single application for magnesium, accounting for over 55% of non-socialist consumption in 1986, is as an alloying agent with aluminum. Aluminum/magnesium alloys have greater tensile strength, increased hardness, better welding properties and superior corrosion resistance than unalloyed aluminum. One of the most important applications for aluminum/magnesium alloys has been in beverage cans, which contain about 1.9% magnesium. With greater recycling of can scrap in recent years, the demand for magnesium in this application has decreased somewhat.

The second largest use for magnesium is for structural applications, of which pressure diecast products constitute the most important component. After increasing from 21 000 t in 1982 to an estimated 37 000 t in 1987, the International Magnesium Association forcasts that magnesium consumption in pressure diecastings will increase to 55 000 t in 1991.

As automobile manufacturers increase the fuel efficiency of their products, the use of lightweight parts including those of diecast magnesium is growing. Among some new or likely automotive applications for magnesium are transmission and transfer cases, clutch housings, intake manifolds, wheel rims, covers for grills, air cleaners, valves and engine blocks.

During 1987, Dow Chemical and the Pontiac Motorsports Division of General Motors Corporation unveiled a new 11.5 kg magnesium engine block. Although specifically designed for use in racing, the engine could have potential applications in passenger cars.

While the greater use of magnesium by the automobile industry is no doubt the result of more rigorous fuel economy requirements that have been adopted in the United States, high-purity magnesium alloys can be used in applications that were once considered too corrosive for the metal. In response to concern about corrosion, producers have announced the development of new, higher purity diecasting alloys or are placing more emphasis on existing high-purity products. In addition to new alloys, the use of rapid solidification techniques using conventional powder metallurgy has been found to significantly improve the operating characteristics of finished products.

Aside from automotive applications, diecast magnesium products are widely used in the manufacture of portable tools and sports equipment. Magnesium usage in electronic equipment, particularly computers, has grown substantially and this trend is expected to continue.

Magnesium is also used as a deoxidizing and desulphurizing agent in the ferrous industry. Magnesium demand in this application, which has grown from about 8 400 t in 1982 to an estimated 22 000 t in 1987, is expected to expand to 38 000 t/y by 1991. The metal is also used to produce ductile or nodular iron and as a reducing agent in the production of titanium, zirconium and other reactive metals. Pure magnesium metal is used frequently for cathodic corrosion protection of steel structures, especially underground pipes and tanks. There are many uses for magnesium in the chemical industry including the making of Grignard reagents used in the production of tetraethyl lead for gasoline, although this use has declined in recent years as governments move to cut the use of these additives. Magnesium is also used in the fuel cladding material in Magnox-type nuclear reactors.

The use of magnesium in dry cell batteries is a fairly new application but one which has the potential for future growth in view of several recent design improvements. Unlike zinc-carbon or alkaline batteries, magnesium batteries have extremely long-shelf lives even at extremely high temperatures. This is due to a protective film of magnesium hydroxide which forms on the surface of the metal during storage periods. However, this protective film can cause a delay in the flow of full current when the battery is turned on, making the magnesium battery unsuitable for certain applications.

Potential new applications for magnesium which are currently being investigated, include magnesium/alumina, magnesium/silicon carbide and magnesium/graphite composite castings, hydrogen storage systems utilizing magnesium hydride, and a magnesium-sulphuric acid battery.

OUTLOOK

During the next decade it is expected that overall magnesium consumption will increase at an average annual rate of about 2.5%. While there is a likelihood of a declining market for magnesium in chemical/reduction uses and only limited growth for aluminum alloying, significant growth of demand is forcast for diecast magnesium products and to a lesser extent in desulphurization applications.

Despite this rather optimistic growth rate and the fact that several new foreign magnesium projects were delayed during 1987, it is expected that new developments particularly those being added in Canada, will increase world capacity to at least 350 000 t/y and possibly to well over 400 000 t/y by 1992. Even with the more conservative figure, it is expected that productive capacity will exceed projected consumption by at least 95 000 t.

Magnesium prices have been relatively stable, but the metal has not been competitive with aluminum for some time. However, this gap narrowed during 1987 and can be expected to improve into the 1990s as excess supply will exert considerable downward pressure on magnesium price levels. Despite the fact that this may force higher cost producers out of the industry, it is expected that this will encourage the selection of magnesium for higher volume uses such as automotive parts. In this regard, the widespread utilization of magnesium alloy wheels could potentially increase metal consumption by as much as 220 000 t/y.

Assuming that all Canadian magnesium projects are brought on stream, Canada has the potential to become the largest producer in the world. Aside from the dramatic increase in actual capacity, it will enjoy a significant competitive advantage due to new efficient technologies and low electric power cost.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
CANADA					
35105-1	Magnesium metal, not including alloys, in lumps, powders, ingots or blocks	4.0	4.0	25	2.5
34910-1	Alloys of magnesium; ingots, pigs, sheets, plates, strips, bars, rods and tubes	4.0	4.0	25	free
34911-1	Magnesium alloy ingots, for use in the production of magnesium castings (expires 30/6/88)	free	free	25	free
34912-1	Hardener alloys for use in the manufacture of magnesium castings (expires 30/6/88)	free	free	25	free
34915-1	Magnesium scrap	free	free	free	free
34920-1	Sheet or plate, of magnesium or alloys of magnesium, plain, corrugated, pebbled, or with a raised surface pattern, for use in Canadian manufactures (expires 30/6/88)	free	free	25	free
34925-1	Extruded tubing, of magnesium or alloys of magnesium, having an outside diameter of five inches or more, for use in Canadian manufactures (expires 30/6/88)	free	free	25	free
UNITED STATES					
628.55	Magnesium, unwrought, other than alloys and waste and scrap		8		
628.57	Magnesium, unwrought, alloys, per pound on magnesium content		6.5		
		¢ per lb. of magnesium content + % ad valorem			
628.59	Magnesium metal, wrought		4.5¢ 2.5%		

Sources: Customs Tariff, 1987, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1987), USITC Publication 1910; U.S. Federal Register Vol. 44, No. 241.

TABLE 1. CANADA, CONSUMPTION[1] OF MAGNESIUM, 1980-86

	1980	1981	1982	1983	1984	1985	1986P
				(tonnes)			
Castings and wrought products[2]	1 412	619	574	490	550	453	633
Aluminum alloys and other uses[3]	4 000	5 768	4 431	5 078	6 296	6 129	6 098
Total	5 412	6 387	5 005	5 568	6 846	6 582	6 731

[1] Available data, as reported by consumers. [2] Die, permanent mould and sand castings, structural shapes, tubing, forgings, sheet and plate. [3] Cathodic protection, reducing agents, deoxidizers and other alloys.
P Preliminary.

TABLE 2. CANADIAN IMPORTS/EXPORTS OF MAGNESIUM METAL, 1980-87

	Imports	Exports
	(tonnes)	
1980	3 419	5 316
1981	3 249	6 221
1982	1 972	4 501
1983	3 714	2 500
1984	4 287	4 022
1985	3 925	4 730
1986	3 419	4 729
1987 (Jan.-Sept.)	2 199	3 450

Source: Statistics Canada.

TABLE 3. WORLD PRIMARY MAGNESIUM PRODUCTION, 1982-86

	1982	1983	1984	1985	1986
			(000 tonnes)		
Canada	7.9	6.0	8.0	7.0	8.2
United States	89.9	104.7	144.4	135.9	117.9
U.S.S.R.	77.0	80.0	85.0	85.0	85.3
Norway	35.9	29.9	48.3	54.7	56.5
France	9.6	10.9	12.8	13.8	13.8
Italy	9.9	9.8	8.2	7.9	9.1
China, People's Republic	7.5	8.5	8.5	9.0	9.1
Japan	5.6	6.0	7.1	8.4	9.1
Yugoslavia	4.2	4.7	5.1	4.9	4.5
Poland	0.5	-	-	-	-
Brazil	0.3	0.5	1.2	2.6	4.5
India	0.1	0.1	0.1	0.1	0.1
Total	248.4	261.1	328.7	329.1	318.1

Source: American Bureau of Metal Statistics.
- Nil.

TABLE 4. PRIMARY MAGNESIUM PRODUCTION BY WORLD ZONE[1], 1980-87

Period	Area 1 United States and Canada	Area 2 Latin America	Area 3 Western Europe	Area 5 Asia and Oceania	Total
			(tonnes)		
1980	163 000	-	64 400	9 200	236 600
1981	138 400	-	64 400	5 700	208 500
1982	97 800	-	52 800	5 800	156 400
1983	109 000	-	51 000	6 000	166 000
1984	152 800	1 000	71 600	6 700	232 100
1985	142 900	2 000	80 800	8 200	233 900
1986	130 700	3 700	81 400	8 100	223 900
1987 (Jan.-Sept.)	98 100	3 900	64 000	5 900	171 900

Source: International Magnesium Association.

[1] There is no production in Area 4, Africa and the Middle East.

- Nil.

TABLE 5. PRIMARY PRODUCERS SHIPMENTS BY WORLD ZONE, 1980-87

Period	Area 1 United States and Canada	Area 2 Latin America	Area 3 Western Europe	Area 4 Africa and Middle East	Area 5 Asia and Oceania	Area 6 Other	Total
			(tonnes)				
1980	111 000	17 000	66 000	2 000	23 000	-	219 000
1981	104 000	12 000	61 000	2 000	24 000	-	203 000
1982	85 761	8 347	60 591	1 278	17 731	-	173 708
1983	98 600	9 600	60 400	2 400	33 400	-	204 400
1984	110 100	8 000	66 800	1 600	29 500	-	216 000
1985	102 400	9 400	72 200	2 400	38 400	-	224 800
1986	103 300	11 300	73 600	3 200	35 000	-	226 400
1987 (Jan.-Sept.)	86 100	6 800	49 100	3 800	21 600	7 500	174 900

Source: International Magnesium Association.

- Nil.

TABLE 6. WESTERN WORLD PRIMARY MAGNESIUM CONSUMPTION PATTERN, 1986

Use	North America	Latin America	Western Europe	Africa/ M. East	Asia/ Oceania	Total 1986
			(000 t)			
Aluminum alloying	53.8	4.7	38.1	3.0	25.8	125.4
Nodular iron	3.9	0.3	5.7	0.2	2.2	12.3
Desulphurization	14.2	-	6.0	-	0.1	20.3
Chemical/reduction	14.5	1.4	6.6	-	3.4	25.9
Diecasting	8.9	4.4	13.3	-	2.2	28.8
Other structural products	4.9	-	2.5	-	0.1	7.5
Other	3.1	0.5	1.4	-	1.2	6.2
Total	103.3	11.3	73.6	3.2	35.0	226.4

Source: International Magnesium Association.

- Nil.

Manganese

D.R. PHILLIPS

Manganese is essential for the production of nearly all types of steel, which account for approximately 90% of its consumption. The remaining 10% is consumed in non-metallurgical applications, mainly for the production of alkaline batteries. Due to its critical role in iron and steel production and because there are no acceptable substitutes for the iron and steel industry, manganese is considered a strategic commodity.

CANADIAN DEVELOPMENTS

Chromasco a division of Timminco Limited, mothballed its Beauharnois manganese facility in May 1987 because of declining prices. Two of the three furnaces were idled. Chromasco had a capacity for 50 000 t/y ferroalloys and has produced 50%, 75% and 85% grades of ferrosilicon, ferromanganese and silicomanganese. It will continue to produce ferrosilicon.

Elkem Métal Canada Inc., a subsidiary of Elkem AS in Norway, operated near capacity in 1987 due, in part, to stronger domestic demand and to reduced production at its U.S. facilities. With the closure of Chromasco, Elkem became the only domestic producer of ferromanganese products. It has a capacity of some 120 000 t/y of ferromanganese at its Beauharnois plant. However, actual production of ferromanganese is considerably less as the furnace is also used to produce silicomanganese.

Work undertaken in 1985 as part of the Canada/New Brunswick Mineral Development Agreement on the Plymouth occurrence, located near Woodstock, N.B., established that the deposit contains about 9% manganese. This compares with grades of 35-50% in commercial deposits located in Australia, South Africa, Gabon, India and Mexico. The oxidizing potential of the Plymouth manganese is also low in comparison to the higher grade deposits, a significant disadvantage in the production of battery grade manganese dioxide (EMD) and chemical grade manganese dioxide (CMD).

Canadian imports of manganese contained in ores and concentrates declined 37% in 1987 compared to 1986. Less ore and concentrate was needed because of the closure at Chromasco. The quantity of imports of manganese ores and concentrates from Gabon was largely unchanged from 1986 and accounted for 56% of 1987 total imports. Imports from South Africa declined 73% compared to 1986.

Total imports of ferromanganese, including spiegeleisen, doubled in 1987 compared to 1986, due to increased consumption by the domestic steel industry and as replacement for the loss of production at Chromasco. Imports from Norway increased sixteen fold compared to 1986 and accounted for 43.7% of total 1987 imports.

Silicomanganese, including silicospiegeleisen, more than doubled in 1987 compared to 1986 for the same reasons as the rise in ferromanganese imports. Brazil and South Africa were the main sources.

Exports of ferromanganese declined four fold in 1987 compared to the two previous years. This decline was also attributed to increased domestic consumption of ferromanganese, especially for the production of specialty steels, and to the closure at Chromasco.

INTERNATIONAL DEVELOPMENTS

The U.S.S.R. and South Africa account for about 55% of current world mine production. Production of ores and concentrates in the U.S.S.R. was estimated at 10.5 Mt in 1987, with about 75% of the ore originating at the Kikpol Basin in the Ukraine. In 1986, a new 2 Mt/y manganese mine was brought on stream in the Ukraine.

It was estimated that Samancor Limited, the western world's largest producer of manganese ore, accounted for about 85% of South Africa's production.

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Gabon, the world's fourth largest producer of manganese ore, is a major supplier to the EEC, Norway, United States and Canada. A US$3 billion investment in a 400-mile railway and a harbour near Liberville, which was planned for completion in 1987, could assist its producers of ores and concentrates in maintaining their market share in these countries.

The United States, Japan and the European Economic Community (EEC) are net importers of manganese ore and ferromanganese. They are also the major consumers of ferromanganese.

Japan imported 7 000 t of ferromanganese in 1986, which was about one half of the imports that were averaged in 1983 and 1984. Imports in 1987 were estimated at about 8 000 t. This latter increase was attributed to a greater demand for manganese because of a higher production of specialty steels. The production of ferromanganese in 1987 was estimated at 400 000 t, a decline of 20% from the previous year because of plant closures.

Western Europe's consumption of ferromanganese in 1987 was estimated at 1.2 Mt of contained manganese, a growth of about 17% over 1986 as a result of an increased production of specialty steels.

The consumption of ferromanganese in the United States in 1987 was estimated at 540 000 t, an increase of about 12% over 1986 consumption, which was attributed to a strong performance in most sectors of the U.S. steel industry.

Elkem's ferromanganese facility at Marietta in Ohio, which upgraded manganese ore from the U.S. stockpile to ferromanganese in 1986, planned to convert an additional amount of ore to 60 000 t of ferromanganese in 1987 and about 106 000 t in 1988. The upgrading program is part of a barter agreement between the U.S. General Services Administration (GSA) and Elkem; upgrading is exchanged for tungsten ores and concentrates from the U.S. strategic stockpile. Although the program was initiated in 1982 by a directive from President Reagan as part of a United States plan to sustain ferroalloy production necessary for national defence purposes, the conversion did not begin until 1984.

USES

The excellence of manganese as a desulphurizer has made this metal an irreplaceable input in the steel industry. Sulphur in steel tends to migrate to the grain boundaries and causes steel to crack and tear during hot rolling and forming. Manganese combines with the sulphur to produce manganese sulphide inclusions, which do not migrate to the grain boundaries. The metal also acts as a deoxidizer during the steelmaking process.

Manganese is usually added to steel in the form of a ferroalloy such as ferromanganese or silicomanganese. Steel mills in Canada use about 5.8 kilograms (kg) of manganese per t of crude steel produced.

Specialty steels frequently contain manganese to increase strength and hardness. Manganese metal is normally used in preference to ferromanganese for making these specialty steels because it provides better control of the manganese and impurities content.

Hadfield steels, a type of specialty steel, contains between 10 and 14% manganese. These steels are extremely hard and tough, and are particularly suited for applications such as rock crusher parts and teeth in earth-moving machinery.

Iron used for castings is desulphurized with manganese. Otherwise, the sulphur causes surface imperfections and makes precision casting difficult.

Also, manganese is used to form alloys with nonferrous metals: aluminum-manganese alloys are noted for their strength, hardness and stiffness; manganese-magnesium alloys are hard, rigid and corrosion resistant; and manganese bronzes have properties desirable in specific applications such as ship propellers.

Manganese has many nonmetallurgical applications including its use in dry-cell batteries. In this role, manganese dioxide provides oxygen to combine with hydrogen, which permits the battery to operate at maximum efficiency. Manganese ores used for batteries must grade above 85% manganese dioxide and have a low iron content. Very few natural manganese ores can meet these specifications and, as a result, most batteries contain a blend of natural ore and synthetic manganese dioxide.

A common classification of manganese ores gives rise to the following ore types: (1) Manganese ores containing more than 35% manganese: these are used in the manufacture of both low and high grade ferromanganese. Although battery-grade ores are included in this class, these ores must contain no less than 85% manganese dioxide. (2) Ferruginous manganese ores containing 10 to 35% manganese and used in the manufacture of spiegeleisen. (3) Manganiferous iron ores containing 5 to 10% manganese and used to produce manganiferous pig iron.

All types of manganese ores can be employed in the production of manganese chemicals such as: potassium permanganate, a powerful oxidant used in the purification of public water supplies; manganese oxide, an important addition to welding rods and fluxes; and an organometallic form of manganese, which inhibits smoke formation and improves the combustion of fuel oil. Various manganese chemicals are employed to produce colour effects in face bricks and, to a lesser extent, to colour or decolour glass and ceramics.

PRICES

The price of manganese ore has gradually weakened over the past two years. However, prices for high carbon ferromanganese increased by 20% in 1987 to US$380 per ton. This rise was attributed to increased consumption of manganese in Japan, the EEC and the United States for the production of most types of steel, and to higher prices in South Africa because of the weakening rand.

OUTLOOK

Producers of metallurgical grade ore will continue to face excess supply during the foreseeable future. Mine capacity exceeds current demand by about 35% and, since no major changes are indicated at the mines and consumption will stay flat or decline slowly over time, no relief is in sight. Ore prices will continue to be weak in both the short and longer terms. The outlook for battery and chemical grade ores is somewhat better, but this is a specialized product and accounts for only 10% of total manganese requirements.

Although the consumption of standard grade ferromanganese and its price have increased over the past year, the fundamental characteristics of the industry suggest the market will return to oversupply and weak prices. Strong demand for ferromanganese is expected to continue for at least the first half of 1988 because of general increases in steel production, particularly in the specialty steel sector. However, the ferromanganese industry is still using only about 65% of its capacity and additional supplies can be put on the market in a relatively short time span.

Over the longer term, idle capacity in western countries will probably be used to produce silicomanganese and new capacity for standard grade ferromanganese will be brought on stream in Brazil and India. On balance, there will probably be an overall expansion of capacity for all metallurgical grade products while aggregate demand for such products will either stagnate or decline slightly. The general trend to declining use of ferromanganese and rising use of silicomanganese will probably continue, but at a slower pace.

Historically, the manganese metal market has been stable. The nominal price has gradually increased, largely in line with costs, suggesting that supply has been closely matched to consumption. However, new metal producers in Australia and Brazil were scheduled to begin production in 1987 and 1988. These new producers could have a destabilizing influence on the manganese metal market.

PRICES

United States prices in U.S. currency, as published by **Metals Week**

	December 1985	December 1986	December 1987
		($)	
Manganese ore, per long ton unit (22.4 lb.) c.i.f. U.S. ports, Mn content Min. 48% Mn (low impurities)	1.40-1.45	1.35-1.40	1.28-1.40
Ferromanganese, f.o.b. shipping point, carload lots, lump, bulk			
Standard 78% Mn, per long ton	320.00-330.00	305.00	380.00-390.00
		(cents)	
Medium-carbon, 80-85% Mn, per lb. Mn	31.00-33.00	32.00-34.00	37.00-38.00
Silicomanganese, per lb. of alloy, f.o.b. shipping point, 65-68% Mn, 16-18.5% Si, 0.2% P, 2% C	15.50-16.50	17.00-18.25	22.50-24.00
Manganese metal, per lb. of product, f.o.b. shipping point			
Regular, minimum 99.5% Mn	80.00	80.00	86.00
6% N, minimum 93.7% Mn	86.00	86.00	NQ

f.o.b. Free on board; c.i.f Cost, insurance and freight; NQ Not quoted.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
CANADA					
32900-1	Manganese ore	free	free	free	free
33504-1	Manganese oxides	free	free	free	free
35104-1	Electrolytic manganese metal	free	free	20%	free
37501-1	Ferromanganese, spiegeleisen and other alloys of manganese and iron, not more than 1% Si, on the Mn content, per lb.	free	0.4¢	1.25¢	free
37502-1	Silicomanganese, silicospiegel and other alloys of manganese and iron, more than 1% Si, on the Mn content, per lb.	free	0.70¢	1.75¢	free
UNITED STATES (MFN)			(%)		
601.27	Manganese ore, including ferruginous manganese ore and manganiferous iron ore, all the foregoing containing over 10% Mn		free		
606.26	Ferromanganese, not containing over 1% C, per lb. Mn content		2.3		
606.28	Ferromanganese containing 1 to 4% C, per lb. Mn content		1.4		
606.30	Ferromanganese containing over 4% C, per lb. Mn content		1.5		
632.28	Manganese metal waste and scrap		5.6		
632.30	Manganese metal, unwrought		14.0		

Sources: Customs Tariff, 1987, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1987), USITC Publication 1910; U.S. Federal Register Vol. 44, No. 241.

TABLE 1. CANADA, MANGANESE, TRADE AND CONSUMPTION, 1985-87

	1985		1986[P]		1987[e]	
	(tonnes)	($)	(tonnes)	($)	(tonnes)	($)
Imports						
Manganese in ores and concentrates[1]						
Gabon	74 502	10 870 823	33 654	5 712 751	33 439	5 424 000
France	-	-	35 746	6 291 199	13 132	2 594 000
United States	4 049	1 810 149	2 726	1 233 595	3 829	1 268 000
Mexico	5 100	481 572	-	-	6 541	1 223 000
South Africa	7 726	1 111 900	11 543	1 240 146	3 041	425 000
Brazil	10 825	2 083 385	11 221	1 931 566	-	-
Argentina	-	-	26	8 649	-	-
Total	102 202	16 357 829	94 916	16 417 906	59 982	10 934 000
Manganese Metal						
South Africa	2 974	6 193 652	1 892	3 912 495	1 617	3 274 000
United States	460	1 285 575	678	1 918 157	305	633 000
United Kingdom	76	208 094	10	25 448	160	444 000
People's Republic of China	225	392 851	75	133 877	97	194 000
Japan	-	-	-	-	94	137 000
Belgium-Luxembourg	22	24 711	-	-	-	-
Total	3 757	8 204 883	2 655	5 989 977	2 272	4 682 000
Ferromanganese, including spiegeleisen[2]						
Norway	1 500	1 055 014	1 092	833 905	17 600	9 475 000
United States	10 076	9 131 770	5 897	5 291 184	5 691	3 630 000
France	2 195	2 450 115	47	146 182	5 357	2 112 000
South Africa	7 002	2 984 220	2 479	1 579 118	5 313	1 976 000
Spain	-	-	1 737	1 671 807	1 600	1 808 000
Mexico	1 800	1 339 188	6 022	4 666 969	2 000	1 432 000
Belgium-Luxembourg	-	-	-	-	1 339	1 125 000
West Germany	4 917	3 387 620	-	-	1 345	1 006 000
Brazil	-	-	585	447 847	-	-
United Kingdom	-	-	1 223	1 412 832	-	-
Switzerland	-	-	1 206	850 728	-	-
Total	27 490	20 347 927	20 288	16 900 572	40 245	22 564 000
Silicomanganese, including silico-spiegeleisen[2]						
Brazil	1 067	490 664	2 000	943 000	5 733	2 742 000
South Africa	2 040	875 184	-	-	5 885	2 469 000
Norway	707	411 419	3 164	1 567 425	2 213	1 108 000
United States	2 786	1 916 301	1 609	1 226 170	807	837 000
Total	6 600	3 693 568	6 773	3 736 595	14 638	7 156 000
Exports						
Ferromanganese[2]						
United States	43 410	16 845 935	45 090	16 946 652	11 660	3 497 808
Japan	-	-	-	-	73	14 300
Total	43 410	16 845 935	45 090	16 946 652	11 733	4 663 744
Consumption[3]						
Manganese ore	160 241	..	197 012	..	205 000	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Mn content; [2] Gross weight. [3] Available data as reported by consumers.
[P] Preliminary; [e] Estimated; - Nil; .. Not available.
Note: Components may not add due to rounding.

TABLE 2. CANADA, MANGANESE IMPORTS, EXPORTS AND CONSUMPTION, 1970, 1975, 1979-87

	Imports			Exports	Consumption[2]	
	Manganese Ore[1]	Ferro-Manganese	Silico-Manganese	Ferro-Manganese	Ore	Ferromanganese and Silicomanganese
			(gross weight, tonnes)			
1970	115 052	17 891	975	510	153 846	97 952
1975	69 773	35 701	5 732	1 168	160 976	95 869
1979	45 150	83 700	21 876	12 043	64 699	89 429
1980	95 161	26 704	20 901	11 278	157 680	95 796
1981	119 746	36 656	12 669	57 040	288 908	83 886[r]
1982	71 655	25 088	2 877	11 738	130 826	69 166
1983	42 260	18 259	460	2 631	99 697	86 111
1984	77 545	29 805	6 083	1 592	108 913	95 049
1985[r]	102 202	27 490	6 600	43 410	160 241	93 984
1986[p]	94 916	20 288	6 773	45 090	197 012	86 687
1987[e]	59 982	40 245	14 638	11 733	205 000	132 000

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Mn content. [2] Available data as reported by consumer.
[p] Preliminary; [r] Revised; [e] Estimated.

TABLE 3. WORLD PRODUCTION OF MANGANESE ORES, 1986 AND 1987 AND RESERVES, 1987

	Mn	Ore Production		Reserves
		1986[r]	1987[e]	1987[e]
	(%)	(000 tonnes)		(Mt)
U.S.S.R.	30-33	11 000	10 500	2 500
Republic of South Africa	30-48+	4 100	4 500	8 500
Brazil	38-50	3 000	3 800	180
Gabon	50-53	2 600	2 900	440
Australia	37-53	1 900	2 200	480
People's Republic of China[e]	20+	1 800	2 100	110
India	10-54	1 350	1 500	70
Mexico	27+	450	750	31
Other countries[1]	..	800	1 000	67
Total	..	27 000	29 250	12 311

Source: U.S. Bureau of Mines, "Mineral Yearbook", 1985.
[1] Includes 19 countries, each producing less than 24 000 t/y.
[e] Estimated; [r] Revised; .. Not available.

Mica

D. SHAW

SUMMARY

Mica is a group name for a number of hydrous aluminum silicate minerals whose crystals exhibit excellent basal cleavage and split easily into tough, flexible sheets. Commercial mica includes both the muscovite and phlogopite varieties. Sheet mica is extracted from enormous crystals and worked by hand to obtain blocks, sheets and splittings. These types are valued by electrical and electronics industries for their dielectrical, optical and mechanical properties. Scrap or waste mica is obtained from the production of sheet mica, while flake mica is recovered from fine-grained micaceous rocks. These latter two types of mica are often indistinguishable in trade, and are ground and classified according to particle size. Traditional filler markets include gypsum compounds, oil well drilling muds, and paint industries; however there has been a recent growth in its use as a reinforcement agent in plastics.

Canada is the world's leading producer of ground and flake phlogopite. Production originates from one mine situated near Parent in Suzor Township, Quebec with a processing plant located in Boucherville, near Montreal. Since Lacana Petroleum Limited acquired the Suzorite operation, a major expansion program which includes new investment of $14 million over several years is under way. The program will center on increasing its capacity to produce delaminated grades suitable for plastic applications.

In 1986, Canadian imports of ground, block and sheet mica were 1 701 t with a total value of $724 000.

Estimated world production of mica in 1986 was 262 700 t, up 4% from 1985. Despite reduced production of ground mica, as a result of depressed demand conditions from Gulf and North Sea well drilling industries, the United States accounted for more than half of world production. Over the last two years, the United States mica industry has undergone a restructuring which included 4 acquisitions, 4 new expansion programs and 1 plant closing.

The plastics industry is expected to be the primary sector of growth for the consumption of mica over the next decade. Chemically-modified mica grades will be increasingly popular in polypropylene compounds, providing plastic producers with competition for more expensive substitutes. Over the next year, however, a rebound in mica consumed by the well drilling sector is forecast. Expectations of stable and moderately rising world oil prices should provide a better climate for suppliers to this industry.

MINERALOGY AND GEOLOGY

Mica is a platy mineral (or family of minerals) occurring in a variety of complex, isomorphic, hydrous aluminum potassium silicate forms. Essentially, most mica types crystallize in the monoclinic system and display excellent basal cleavage which permits their splitting into very thin laminae that are tough and flexible at high temperatures, and retain unusual electrical properties. The principal mica minerals are muscovite $KAl_2(AlSi_3O_{10})(OH)_2$, phlogopite $KMg(AlSi_3O_{10})(OH)_2$ and biotite $K(Mg,Fe)(AlSi_3O_{10})(OH)_2$.

By and large, only muscovite (potassium or white mica) and phlogopite (magnesium or amber mica) varieties are of commercial importance. Colour varies from black to virtually colourless. Hardness is approximately 2 to 3 on the Mohs' scale, and density ranges from 2.6 to 3.2 g/cm^3.

Muscovite is a common constituent of acid igneous rock, such as granites, pegmatites and aplites. Pegmatites, the primary source of quality sheet mica, are composed of feldspar, quartz and mica: associate minerals include garnet, tourmaline and beryl. Phlogopite is particularly common in

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ferromagnesian basic rock such as pyroxenites, metasedimentary crystalline limestones, peridotite and dunites.

CANADIAN DEVELOPMENTS

Consumption and trade

Canada does not have a large consumer market for mica products. Gypsum caulking products and paint account for more than 82.9% of mica consumption in Canada, while rubber, plastics and drilling mud industries share the remaining 17.1%.

Canada imports ground mica from the United States, mica blocks and sheet from India and fabricated mica products from the United States, France, India and the United Kingdom. Imports of ground, block and sheet mica for the first nine months of 1987 were 1 701 t. This figure is almost identical to the imports reported for the same period in 1986. In that year, total imports of ground, sheet and block mica was 2 174 t.

Canadian phlogopite mica is used locally in gypsum products, rubber, plastics and drilling mud industries. However, most Canadian mica production is exported to the United States (50%), Japan (20%) and western Europe (5%).

Production and deposits

The sole Canadian mica operation at present is Suzorite Mica Products Inc., a division of Lacana Petroleum Limited of Toronto. The company mines phlogopite in Suzor Township, Laviolette County, and further processes flake mica at its plant located in Boucherville, east of Montreal. The deposit has a unique assemblage of schistose rock which contains approximately 80 to 90% phlogopite, 4 to 8% pyroxene, 2 to 6% perthite, and traces of apatite, calcite and chlorite. Phlogopite reserves are estimated at more than 27 Mt of homogeneous ore.

The ore is mined by open-pit methods on an intermittent basis every two years. A Kennedy Jaw Crusher breaks the ore to smaller than 20 cm prior to shipment by rail twice each year to the Boucherville processing plant. The ore is then dry ground, concentrated in a pneumatic separator and classified according to four sizes: -10 +20 mesh, -20 +40 mesh, -40 +100 mesh, and over 100 mesh. Up to 24 grades of mica are produced at this plant.

Tailings of feldspathic materials are distributed as waste material. Flake mica, registered under the trade name of Suzorite, is used as a reinforcing agent in plastics and composites. The ground varieties of phlogopite act as a filler in asphalt products, in gypsum caulking products, and in oil-well drilling muds.

Since Lacana Petroleum Limited acquired Suzorite Mica Products Inc. from Marietta Resources International Ltd., a major expansion program has been undertaken. This program involves the expenditure of $14 million over several years for the purpose of expanding production capacity to 25 000 t/y, particularly for delaminated high aspect ratio products; the modernization of its research facilities; the development of new mica products, primarily for plastic applications; and to improve the dust collection system. In 1986, $2.7 million in expenditures were made to upgrade the plant, and in 1987, $2.0 million was invested, primarily for the expansion of storage facilities.

In 1987, production of phlogopite mica rose 12.5% over the previous year. A newly-introduced mica grade, E-Mica, was developed and is currently being marketed for reinforcement in electromagnetic interference plastic shieldings. E-Mica is a nickel coated mica that can be used as an electroconductive filler in the production of strong conductive plastics for housings or microprocessors and other sensitive electronic components. This product's loading levels vary between 10 and 35% depending upon its application.

Occurrences of mica have been discovered at several sites in Canada. Muscovite is particularly common in pegmatitic intrusions. Interesting occurrences are located in the following Ontario townships: Addington, Calvin, Canney, Chapman, Chisholm, Christie, Clarendon, Davis, Deacon, Hungerpond, Kaladar, Lennox, Mattawa, McKonkey, Ohig and Sheffield. In Quebec, muscovite is found in the counties of Abitibi-Temiscamingue, Charlevoix, Dubuc and Sagueney; in British Columbia, near Yellowhead Pass, the Big Ben District of the Columbia River, and in the District of Fort Grahame.

In Canada, phlogopite is virtually confined to the northeastern belt of the Grenville series. The major occurrences of phlogopite are found in the Quebec counties of Argenteuil, Gatineau, Hull, Labelle, Laviolette, Montcalm, and Papineau; and in the Ontario counties of Frontenac and Lanark.

WORLD DEVELOPMENTS

World production of mica is best broken down according to the type of mica. India is the largest source of muscovite sheet mica, followed by Brazil, Madagascar and Argentina. The United States, the largest producer and consumer of ground and flake mica, produces muscovite by wet and dry methods, generally as a coproduct of kaolin, lithium or feldspar. Canada, Finland and Argentina produce ground, flake and micronized phlogopite.

In 1986, estimated world production of mica grew 4% over the previous year to 262 700 t, with the United States accounting for over one-half of this total. The increase was due largely to increased production of scrap and flake mica in the United States.

In the **United States** shipments of ground mica, from scrap and flake mica, decreased 7% in 1986 to 115 000 t, valued at US$23.9 million. This drop was due, in a large part, to lower sales of mica for well-drilling mud applications. Twelve companies operated fifteen grinding plants in 1986, and the industry profile highlighted two major acquisitions. Kings Mountain Mica Co. Inc. acquired United States Gypsum Company's dry-grinding plant located at Kings Mountain, N.C. The company also consolidated its operations and was renamed KMG Minerals Inc. Unimin Corp. acquired its second mica operation, Harris Mining Co., and subsequently announced its intention to upgrade these facilities, including a doubling of capacity by mid-1987.

In **India,** exports of processed mica in 1986 were about 24 375 t, surpassing all previous years' performances. The U.S.S.R. remains India's largest export market, purchasing about 60% of India's mica block sales and about 25% of its splittings and film sales.

In **Spain,** Caolines de Vimianzo SA (Cavisa), a subsidiary of Rio Tinto Minera SA, announced its intentions in 1987 to construct a plant for the recovery of mica from its existing kaolin operations located in northwest Spain. Plans include the production of 12 000 t/y, commencing in June 1987. The US$1 million plant will recover muscovite from the underflows of cyclones used in the processing of kaolin. Cavisa's product will contain 48% SiO_2 and 8% K_2O, with a particle size maximum 30% passing 106 microns, and will be marketed in England, Germany and Italy.

In **Zimbabwe,** CRM (Pvt.) Ltd. took over the activities of Mitmar (Pvt.) Ltd. the Zimbabwean beryl and mica producer. Zimbabwean mica production of 1 200 t in 1986 is exported solely to South Africa.

USES AND SPECIFICATIONS

The principal commercial types of mica are muscovite (accounting for over 80% of commercial trade) and phlogopite; both of which are utilized in sheet and flake forms. Ground mica, produced from scrap and flake either as a dry-ground (75% of production), wet ground or micronized product is consumed in the greatest volume.

Sheet mica is used for its electrical and insulating properties, principally in electronic applications. However, electrical and electronic uses for smaller grades of sheet mica have declined rapidly due to the introduction of the printed circuit and the silicon chip. New markets such as special optical filters, retardation plates in helium-neon lasers, gap separators in computer recording heads, and gold or silver-coated sheet mica for communication devices look promising. Sheet mica is graded according to thickness: blocks must be thicker than 0.007 in. (0.18mm); films between 0.0008 and 0.004 in. (0.0206-0.1028mm); and splittings approximately 0.0011 in. (0.0028mm).

Sheet muscovite is also used to manufacture micanite, mica paper, glass-bonded mica and phosphate-bonded mica. These fabricated mica products represent cheaper alternatives to sheet mica. Since the dielectric properties of muscovite are better than those of phlogopite, transparent muscovite is the most common variety used in these sectors. The specifications for sheet mica comply with the standards of the American Society for Testing Materials (ASTM). Designation ASTM-D351-62 specifies quality according to stain, inclusions and imperfections. Designation ASTM-D2131-65 provides the required characteristics for mica product manufacture. Designation ASTM-D748-59 defines the requirements for electrical, physical and visual properties of the mica sheets used in capacitors.

Ground and micronized mica are used as fillers in building products and paint, as a reinforcement in plastics, and as a component in oil-well drilling muds.

Dry wall products and joint cement compounds constitute the major end-use of mica. Mica prevents cracking and provides good workability due to its structural quality. The product should be free of grits, and its particle sizing should be less than 150 microns. Muscovite is occasionally preferred over phlogopite as it is virtually colourless. In this use, the principal substitutes for mica are talc, clay and asbestos.

Mica is used in asphalt roofing products, primarily as a dusting agent but also as a filler in asphalt mixtures to improve their resistance to weathering. Dry-ground mica varies from 850 to 75 microns (20 to 200 mesh) in size.

Paint often requires fillers to improve its surface qualities. Mica reduces shrinkage, prevents cracking and improves resistance to weathering. The mineral is used in exterior paints, anticorrosive emulsions and oil-based metal primers. Wet-ground or micronized mica should be transparent and should have particle sizes in the order of 100, 160 and 325 mesh.

Mica is used in rubber materials as a dusting and releasing agent, as well as a filler to reduce gas penetration and shrinkage during moulding. Generally in these applications 850 to 150 micron flakes are required.

Plastics are a rapidly growing application for mica, especially in polypropylene and high-density polyethylene compounds for the automotive industry. Reinforcement of plastic resins with mica flakes, by replacing or supplementing other fibrous minerals such as wollastonite and asbestos, has been growing due to the commercial availability of high aspect ratio and surface-treated mica grades. The resulting plastics have high modulus of elasticity, flexural and tensile resistance, increased heat distortion and deflection temperatures, low permeability and good resistance to weathering. Delaminated micas are treated with coupling agents to improve their cohesion with resins. These grades are the most expensive and they are substitutes for higher cost glassfibre. Loading levels range from 20 to 50% by weight. These ground micas have a particle size range from 425 to 45 microns.

Other principal uses of various types of mica include: mica splittings for built-up mica products such as moulding plates, segment plates, heater plates and tapes; dry-ground mica for insulation board, oil-well drilling muds, welding electrodes, acoustic products, adhesives, fire extinguishers, foundry coatings, lubricants and composite cement materials; wet-ground mica for wallpaper and lubricants.

PRICES

Prices for mica are based on type, grade and quality. Sheet mica grades are generally 10 times more valuable than ground mica grades. Prices for ground mica have increased significantly in the last six years, reflecting a shift in demand for higher value grades and the more sophisticated chemically-treated mica varieties. In 1987, the value of imported ground and sheet mica averaged $426.00/t.

OUTLOOK

North American production capacity of ground mica exceeds demand, however, optimistic forecasts of expanding markets, particularly in plastic applications, have resulted in the past year's upgrading and expansion of existing facilities in tandem with the exploration of new deposits. This optimism is linked to expectations of improved economic performance of the construction, plastics and drilling mud industries. However, low capacity utilization rates of today are expected to persist for the rest of this decade.

The construction and paint industries are the two greatest market applications of ground mica. In 1986, Canadian housing starts and gypsum products shipments grew in excess of 20% over 1985 levels, while the United States experienced a more moderate 5% growth rate. In the longer term the construction and paint industries performances should be linked to overall economic activity. Current forecasts of annual growth in both Canadian and American gross national products for the next two years range between 2.5 and 3.5%. As no new substitutes for mica in either gypsum joint compounds or paint appear to be emerging, this latter range of moderate growth may best be echoed for the construction and paint industries' consumption of mica.

The greatest potential for growth in the consumption of mica over the next decade will occur in the plastics industry. Polypropylene and polyethylene resins, primarily destined for automotive markets, are well established consumers of mica. Moreover, recent developments indicate opportunities exist for mica in thermoplastics, particularly polyester and nylon. Canadian and American shipments of plastic products in 1986 grew by 6 and 5%, respectively, over 1985. In the longer term continued growth in the demand for plastics in excess of 6%/y is forecast. As plastics find new and wider applications in packaging, cans and containers, automotive and electrical industries, mica consumption will grow a particularly high aspect ratio and surface-treated mica products.

Chemical modification of mica with azido and amino silanes, organosilicon chemicals, calcium stearate, organometallic and chlorinated parrafin are generally employed to improve the compatibility of the mineral with the polymer. The outlook for these products presents business opportunities to mineral suppliers interested in value-added production. Depending on the mineral and type of treatment, chemical modification can add 3.5¢ to 50¢/lb. to the cost of the mineral. Sales of treated mica in North America are forecast to expand 19% annually until the end of this decade.

Since the rapid decline of world oil prices in January 1986 the North American well drilling industry has been in recession. Oil and gas wells completed in the United States for the first half of 1987 was down 29% from the same period in 1986. The year 1986 saw the fewest wells completed in the United States in over a decade. In Canada, however, oil drilling rebounded as producers took advantage of a five-year royalty holiday on new wells drilled before November 1987 and a federal assistance program that covers one-third of drilling costs up to $3 million. Slow and erractic growth in mica consumption is expected in the short term as forecasts of sluggish oil markets persist.

PRICES

Average price[1] for wet-ground and dry-ground mica in the United States	US$ per short ton	
	1985	1986
Wet-ground mica	407	419
Dry-ground mica	130	140
By uses:		
well-drilling mud	106	108
paint	174	165
joint cement compounds	152	167
plastics	218	216

Prices for mica in the United States, according to the Chemical Marketing Reporter[2]	US$ per lb.
	1987
Dry-ground mica: joint cement, plastics, 50-pound bags, carload, works	.07½
Dry-ground mica: roofing products, 20 to 80 mesh sieves, point of shipping	.07
Wet-ground mica: paints, per carload, 325 mesh sieve, f.o.b., works	.16¾
By uses; carload, f.o.b., works	
rubber products	.16¾
wallpaper	.22

Prices for phlogopite[3], f.o.b., works, carload	C$ per short ton	
	1985	1986
Super delaminated fine mica	248-443	260-470
Surface-treated mica	680-740	695-750
Flake or ground mica	295-410	310-438
Drilling fluid mica	113-177	170-194

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[1] U.S. Bureau of Mines, 1985 and 1986, Mica. [2] CMR, December 1987. [3] Suzorite Mica Products Inc., July 1, 1986.
f.o.b. Free on board.

TABLE 1. CANADA, MICA IMPORTS, 1985-87

	1985		1986		1987P	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Mica in blocks, films, sheets and ground						
United States	2 275	929	2 174	878	1 683	699
India	35	48	0	0	18	25
Subtotal	2 310	977	2 174	878	1 701	724
Fabricated mica, n.e.s.						
United States	..	2 506	..	2 857	..	1 701
France	..	271	..	686	..	312
India	..	130	..	196	..	319
United Kingdom	..	113	..	1	..	170
Switzerland	..	16	..	0	..	0
West Germany	..	0	..	0	..	0
Hong Kong	..	0	..	0	..	0
Subtotal	..	3 036	..	3 740	..	2 502
Total rough, sheet, ground and fabricated mica	..	4 013	..	4 618	..	3 226

Sources: Energy, Mines and Resources Canada; Statistics Canada.
Note: As figures have been rounded, sums may not correspond to the totals indicated.
P Preliminary first nine months only; n.e.s. Not elsewhere specified; .. Not available.

TABLE 2. REPORTED CONSUMPTION[1] OF MICA IN CANADA, 1984-86

	1984^r	1985	1986P
		(tonnes)	
Gypsum products	1 864	2 576	2 764
Paint and varnish	151	150	166
Other products[2]	459	379	404
Total	2 474	3 105	3 334

[1] Reported from EMR survey on the consumption of nonmetallic minerals by Canadian manufacturing plants. [2] Includes bearings and brake linings, rubber products, well-drilling muds, foundries, chemicals and other miscellaneous products.
P Preliminary; ^{r} Revised.

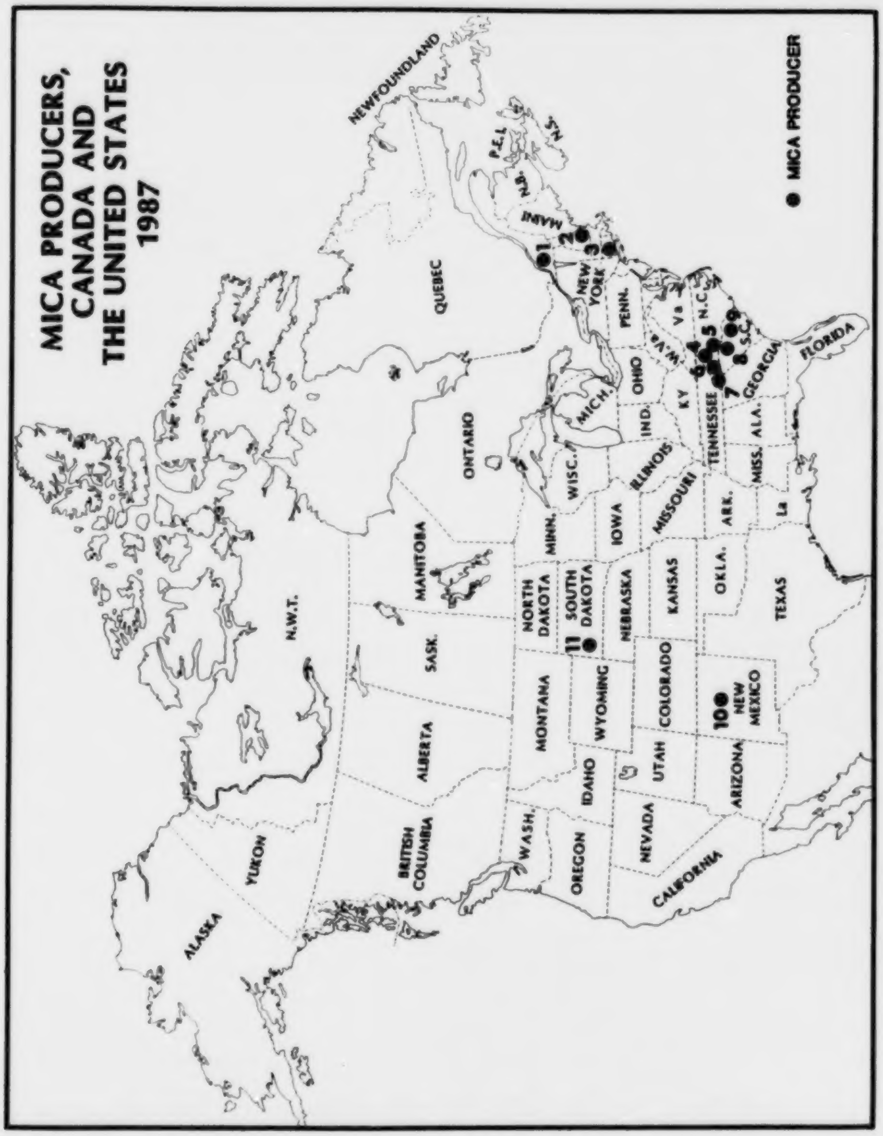
TABLE 3. WORLD PRODUCTION[1] OF MICA (ALL VARIETIES), BY COUNTRY 1983-86

	1983	1984	1985	1986[e]	Remarks
	(tonnes)				
United States[2]	127 000	146 000	125 200	134 300	Muscovite, flake and scrap
U.S.S.R.[e]	48 990	48 990	49 900	49 900	All varieties
India[e]	19 070	19 070	25 610	25 610	Muscovite, exports and local consumption, sheet and flake
Korea Republic	14 400	24 440	20 040	20 000	Muscovite, coproduct of kaolin and feldspar, scrap
Canada[3]	11 000	11 000	11 000	12 000	Phlogopite, flake and ground
France[e]	9 290	10 850	9 980	9 070	Muscovite, coproduct of kaolin
Brazil	3 600	3 600	1 900	2 990	Muscovite, sheet
South Africa	2 670	4 480	2 070	2 090	
Morocco	500	1 200	1 440	1 500	
Mexico	1 560	1 680	1 450	1 410	All varieties
Other countries[4]	4 700	4 790	4 360	3 830	
World total	242 780	276 100	252 950	262 700	

Source: U.S. Bureau of Mines.

[1] U.S. Bureau of Mines, Mica; Lawrence Davis, 1986. [2] Excluding the production of sericite estimated at 38 100 tonnes in 1986. [3] Shipments estimate. [4] Argentina, Madagascar, Mozambique, Spain, Sudan, Yugoslavia, Taiwan, Zimbabwe, Finland, Romania, the People's Republic of China and Pakistan are other mica producers.

[e] Estimated.



MICA PRODUCERS, CANADA AND THE UNITED STATES 1987

● MICA PRODUCER

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NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLA.
TEXAS
MONTANA
WYOMING
COLORADO
NEW MEXICO
IDAHO
UTAH
ARIZONA
WASH.
OREGON
NEVADA
CALIFORNIA

Company	Parent Corporation	Plant Capacity (t/y)	Market Application
1. Suzorite Mica Products Inc.	Lacana Petroleum Limited	20 000	Plastics, joint compounds, rubber, well drilling mud
2. Concord Mica	-	1 500	Paint, rubber
3. The Feldspar Corp.	Pacific Tin Consolidated Corp.	-	Captive production for USG Corporation
4. Spruce Pine District, N.C.			
a) The Feldspar Corp.	Pacific Tin Consolidated Corp.	-	Captive production for USG Corporation
b) Lawson-United Feldspar & Minerals Co. Inc.	Falconbridge Limited	-	Captive production for Asheville Mica Corporation
c) USG Corporation	-	27 000	Joint compounds
d) Unimin Corp.	-	46 000	Joint compounds, paint, rubber paint, plastics, well-drilling mud
e) Deneen Mica Co. Inc.	-	23 000	Well-drilling mud
f) J.M. Huber Corporation	-	2 500	Joint compounds
5. Kings Mountain District, N.C.			
a) KMG Minerals Inc.	-	46 000	Paint, plastics, well-drilling mud, adhesives, cosmetics
b) Foote Minerals Company	Newmont Mining Corporation	-	Captive production for USG Corporation
6. Asheville Mica Corporation	-	6 000	Joint compounds
7. Franklin Mineral Products	Mearl Corporation	4 000	Cosmetics, paint, rubber, plastics
8. Lithium Corp. of America	Gulf Resources & Chemical Corporation	18 000	Joint compounds, well-drilling mud
9. Mineral Mining Corporation	-	23 000	
10. Mineral Industrial Commodities of America Inc.	-	36 000	Well-drilling mud, joint compounds
11. Pacer Corp.	-	-	Well-drilling mud, paint

Mineral Aggregates

O. VAGT

Canada's economy recovered substantially since the 1982-84 recessionary period. Since 1985, construction expenditures related particularly to residential building expanded rapidly. The commercial and institutional building sectors performed moderately well, however expenditures related to engineering construction, with gas and oil facilities accounting for up to one-third, continued to be relatively low.

Demand for mineral aggregates generally reflects the trends in construction, and from a regional perspective, residential construction was particularly strong in Ontario and Quebec during 1987. Total aggregate production over the past two years has been in excess of 350 Mt/y. Average unit prices have not changed greatly and continue to fluctuate widely from province to province depending upon the proximity of the resource to the consuming centre. Housing starts, a fair indicator of construction materials demand, rose to 165 826 in 1985, 199 785 in 1986, and to over 240 000 in 1987. Total construction expenditures are expected to be more than $70 billion.

Several provinces continued programs to identify and to assess their aggregate resource base and to project future market requirements. In some instances these programs have been undertaken as part of Mineral Development Agreements under the Economic and Regional Development Agreements (ERDA's) between the federal and provincial governments. The inherent constraints to development of aggregate properties persist as property owners oppose the development of nearby quarries or gravel pits. Awareness of the importance of mineral aggregates to the construction industry has been heightened in recent years and in the case of Ontario a new Planning Act addresses the problem.

A policy statement issued in May 1986 by the Government of Ontario emphasizes the need for wise use of aggregate resources. It is expected that existing pits and quarries will be protected, and that wise planning at the municipal level will apply to future development of non-renewable resources of sand, gravel and stone.

Until recently, none of the principal lightweight aggregates (vermiculite, pumice and perlite) was mined in Canada. Imports, mainly from the United States, supplied domestic requirements for use in both lightweight concrete and gypsum products, for loose insulation applications and for horticultural uses. During 1983, Aurun Mines Ltd. developed a perlite property in central interior British Columbia and the company continues to expand its domestic and export markets.

CANADIAN DEVELOPMENTS

Sand and Gravel

Sand and gravel deposits are widespread throughout Canada, and large producers have established "permanent" plants as close to major consuming centres as possible. In addition to large aggregate operations usually associated with other construction-related activities such as ready-mix or asphalt plants, there are many small producers serving local markets. These are often operated on a seasonal or part-time basis. Many larger operations are short-term, intermittently serving as a supply arm of a heavy construction company, and provide material for a given project. Provincial departments of highways operate regional or divisional quarries to supply roadbed material for new and repair work. Exploitation by such a large number of widely diversified groups not only makes control difficult, it also provides great obstacles to the collection of accurate data concerning both production and consumption of sand, gravel and stone.

Crushed Stone

The large number of stone-producing operations in Canada precludes the description of individual plants or facilities in this publication. Many are part-time or seasonal

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operations, others are operated as subsidiaries of construction or manufacturing establishments not classified to the stone industry, and some are operated directly by municipal or provincial government departments producing stone for their own direct use. Quarries removing rock by drilling, blasting and crushing generally are not operated for small, local needs as often occurs in the case of gravel pits. Rather, these operations are generally associated with large construction-related companies. Depending on costs and availability, crushed stone competes with gravel and crushed gravel as an aggregate in concrete and asphalt, and as railway ballast and road metal. In these applications it is subject to the same physical and chemical testing procedures as the gravel and sand aggregates.

Quarrying operations that can supply high quality construction aggregates or high chemical quality stone for specified uses have been successful on both the east and west coasts where ocean-going barges or other large volume ocean transportation facilities have been used to reduce unit transportation costs. Producers of high calcium limestone on Texada Island in British Columbia have supplied Vancouver and Washington state cement and lime producers with raw material for many years. Construction aggregate from the Strait of Canso area in Nova Scotia has been barged to many Atlantic Canada areas and during the last three years it has been shipped as far as Houston, Texas in 50 000 to 60 000 t shiploads.

The Newfoundland Resources & Mining Company Limited, owned by Explaura Holdings PLC of the United Kingdom, proceeded with plans to develop a limestone aggregate operation on the Port au Port Peninsula, Newfoundland. Shipments of 1 to 2 Mt/y are planned mainly to markets in the United States.

Lightweight Aggregates

Four categories generally used to classify the lightweight aggregates combine elements of source, processing methods and end-use. Natural lightweight aggregates include materials such as pumice, scoria, volcanic cinders and tuff. Manufactured lightweights are bloated or expanded products obtained by heating certain clays, shales and slates. Ultra-lightweights are made from natural mineral ores, such as perlite and vermiculite, which are expanded or exfoliated by the application of heat and used mainly as plaster aggregate or as loose insulation. Fly ash obtained from the combustion of coal and coke, and slag resulting from metallurgical processes, are classed as by-product aggregates.

Perlite: Perlite is a variety of glassy volcanic rock (obsidian) that contains 2 to 6% of chemically combined water. When the crushed rock is heated rapidly to a suitable temperature (760°C to 980°C) expansion occurs between 4 and 20 times its original volume. Expanded material can be manufactured to weigh as little as 30 to 60 kg/m^3, with attention being given to preblending of feed to the kiln and retention time in the kiln.

In Canada, imported perlite is expanded and used mainly by gypsum products manufacturers in plaster products such as wallboard or drywall, and in fibre-perlite roof insulation board, where its value as a lightweight material is augmented by its fire-resistant qualities. It is also used as a loose insulation and as an insulating medium in concrete products. Perlite, vermiculite, and expanded shale and clay are becoming more widely used in agriculture as soil conditioners and fertilizer carriers.

Imports of crude perlite for consumption in Canada are from New Mexico and Colorado deposits, worked by such companies as Manville Corporation, United States Gypsum Company, United Perlite Corp. and Grefco, Inc.

Aurun Mines Ltd. produced perlite from a deposit near Clinton, British Columbia. Processing is done in Surrey primarily for horticultural, insulation, filter-aid and ultrafine markets.

Pumice: In Canada, a number of concrete products manufacturers use pumice imported from Greece or from the northwestern United States, mainly in the manufacture of concrete blocks. A major use for pumice, as yet unexplored in Canada, has been in highway construction, where lightweight aggregate surfaces have been shown to have exceptional skid resistance.

Vermiculite: The term vermiculite refers to a group of micaceous minerals, hydrous magnesium-aluminum silicates, that exhibit a characteristic lamellar structure and expand or exfoliate greatly when heated rapidly.

Canadian consumption is mainly as loose insulating material, with smaller amounts being used as aggregate in the manufacture of insulating plaster and concrete.

The major producer of vermiculite is the United States. The principal company supplying Canada is W. R. Grace and Company, from operations at Libby, Montana and from the Enoree region of South Carolina. Canada also imports crude vermiculite from the Republic of South Africa, where Palabora Mining Co. Ltd. is the major producer.

Vermiculite occurrences have been reported in British Columbia, and deposits near both Perth and Peterborough in Ontario have been investigated but, as yet, no commercial deposits have been developed in Canada.

Clay, shale and slag: Common clays and shale are used throughout Canada as raw material for the manufacture of lightweight aggregates. Although the Canadian industry began in the 1920s in Ontario, it did not evolve significantly until the 1950s when it grew in support of demands from the construction industry. The raw materials are usually quarried adjacent to the plant sites at which they are expanded. Clays receive little beneficiation other than drying before being introduced to the kiln in which they are heated. Shales are crushed and screened before burning.

In steelmaking, iron ore, coke and limestone flux are melted in a metallurgical process. When completed, lime is combined with the silicates and aluminates of the ore and coke, forming slag, a nonmetallic product. After controlled cooling from the molten state, the porous, glassy slag may be crushed and sized for many construction-related applications.

On-going research sponsored through CANMET and relating to supplementary cementing materials led to the successful use of blast furnace slag for manufacturing a slag cement. Reiss Lime Company of Canada, Limited is now producing this type of cement from a grinding plant at Spragg, Ontario, using granulated slag from The Algoma Steel Corporation, Limited, Sault Ste. Marie plant. Plant capacity is 200 000 t/y of slag cement for complete or partial replacement of Portland cement, depending on requirements. The primary use at present is in mine backfill, however, construction-related uses are also being investigated.

PRICES

There are no standard prices for sand, gravel and crushed stone. In addition to supply-demand factors, prices are determined regionally, or even locally, by production and transportation costs, by the degree of processing required for a given end use and by the quantity of material required for a particular project.

USES

The principal uses for sand and gravel are in highway construction and as concrete aggregate. Individual home construction triggers the need for about 300 t of aggregate per unit while apartment construction requires only about 50 t per unit, according to an Ontario Ministry of Natural Resources study.

The construction industry utilizes 95% of total stone output as crushed stone mainly as an aggregate in concrete and asphalt, in highway and railway construction and as heavy riprap for facing wharves and breakwaters. Specifications vary greatly, depending on the intended use, and many tests are required to determine the acceptability of aggregates for certain applications. Particle size distribution of aggregates, as assessed by grading tests or sieve analysis, affects the uniformity and workability of a concrete mix as well as the strength of the concrete, the density and strength of an asphalt mix, and the durability, strength and stability of the compacted mass when aggregates are used as fill or base-course material. Of importance also are tests to determine the presence of organic impurities or other deleterious material, the resistance of the aggregate to abrasion and to freeze-thaw cycles, the effects of thermal expansion, absorption, porosity, reactivity with associated materials and surface texture.

The use of sand and gravel as backfill in mines continues, along with increasing use of cement and mill tailings for this purpose. Abrasive sands, glass sand, foundry sands and filter sands are also produced.

The use of lightweight concrete in commercial and institutional projects has facilitated the construction of taller buildings and the use of longer clear spans in bridges and buildings. Additional advantages from the use of lightweight aggregates lie in the fact that they supply thermal and acoustical insulation, fire resistance, good freeze-thaw resistance, low water absorption and a degree of toughness to the concrete product.

There are as yet no Canadian Standards Association (CSA) specifications for the lightweight aggregates. Production and application are based on the American Society for Testing and Materials (ASTM) designations as follows: ASTM Designations C 332-66 - Lightweight Aggregates for Insulating Concrete; C 330-75a - Lightweight Aggregates for Structural Concrete; and C 331-69 - Lightweight Aggregates for Concrete Masonry Units.

OUTLOOK

Indicators including relatively low interest rates, falling unemployment and moderate consumer prices suggest a continuing positive outlook for the building construction sector. Nevertheless, housing starts are expected to decline particularly in Ontario and Quebec because pent-up demand from the recessionary period has been satisfied. The Alberta economy is expected to continue its recovery based on oil and gas-related investments and this will help broaden construction activity in the western region.

The Canadian Construction Association predicts constant dollar expenditures of about 4% through the 1986-96 period in the non-residential contract construction industry.

Urban expansion has greatly increased demand for sand and gravel in support of major construction. Paradoxically, urban spread has not only tended to overrun operating pits and quarries, but has extended at times to areas containing mineral deposits, thereby precluding the use of these resources. Further complications have arisen in recent years as society has become increasingly aware of environmental problems and the need for planned land utilization. Municipal and regional zoning must be designed to determine and regulate the optimum utilization of land, but must not be designed to provide less than optimum resources utilization. Industry must locate its plants so as to minimize any adverse effects on the environment from their operations. Also, provision must be made for rehabilitation of pit and quarry sites in order to ensure the best sequential land use. The frequency with which small quarries and pits materialize to supply short-lived, local demands, leaving unsightly properties, has prompted action by municipal and provincial governments to control or to prohibit such activity.

On average, total aggregate consumption will rise in line with population increases, housing requirements and construction in general. Sand and gravel consumption will continue in competition with crushed stone and, in some applications, with lightweight aggregates. New reserves must be located, assessed and made part of any community development planning or regional zoning, with optimum land and resource utilization in mind. Prices of aggregates will follow a rising trend with increasing land values, more sophisticated operating techniques and equipment, reduction of readily-accessible reserves and added rehabilitation expenditures.

Estimates have indicated that available sand and gravel supplies in some regions will be depleted by the 1990s. This could make outlying deposits not only attractive but necessary to the continued operation of the Canadian construction industry in certain areas. Predicted shortages could encourage exploitation of underwater deposits and could make underground mining of crushed stone attractive.

TABLE 1. CANADA, TOTAL PRODUCTION OF STONE, 1985-87

	1985		1986		1987P	
	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)
By province						
Newfoundland	600	3 192	476	2 712	535	2 950
Nova Scotia	4 452	23 944	4 023	21 944	4 830	26 000
New Brunswick	2 394	12 168	2 344	13 064	2 465	13 750
Quebec	31 130	148 752	36 066	172 194	37 925	189 625
Ontario	37 180	168 768	45 477	226 130	51 000	260 800
Manitoba	4 155	15 787	4 099	26 831	4 125	28 000
Alberta	225	3 116	229	1 315	260	1 475
British Columbia	6 333	30 440	4 403	23 049	4 085	23 700
Northwest Territories	163	434	484	1 416	450	1 195
Canada	86 632	406 601	97 601	488 655	105 675	547 495
By use						
Building stone						
Rough	280	10 581	..	..	..	..
Monumental and ornamental stone (n.f.)	58	6 527	..	..	..	..
Other (flagstone, curbstone, paving blocks, etc.)	25	1 337	..	..	..	..
Chemical and metallurgical						
Cement plants, Canada	8 467	23 516	..	..	..	..
Cement plants, foreign	546	1 527	..	..	..	..
Lining, open-hearth furnaces	-	-	..	..	..	..
Flux in iron and steel furnaces	1 155	4 893	..	..	..	..
Flux in nonferrous smelters	76	1 761	..	..	..	..
Glass factories	228	4 357	..	..	..	..
Lime plants, Canada	5 137	15 504	..	..	..	..
Lime kilns, foreign	288	1 159	..	..	..	..
Pulp and paper mills	192	1 408	..	..	..	..
Sugar refineries	23	261	..	..	..	..
Other chemical uses	569	4 977	..	..	..	..
Pulverized stone						
Whiting (substitute)	27	1 487	..	..	..	..
Asphalt filler	241	3 152	..	..	..	..
Dusting, coal mines	7	196	..	..	..	..
Agricultural purposes and fertilizer plants	1 219	14 735	..	..	..	..
Other uses	247	9 909	..	..	..	..
Crushed stone for						
Manufacture of artificial stone	9	203	..	..	..	..
Roofing granules	336	1 415	..	..	..	..
Poultry grit	31	822	..	..	..	..
Stucco dash	17	986	..	..	..	..
Terrazzo chips	5	124	..	..	..	..
Rock wool	-	-	..	..	..	..
Rubble and riprap	2 788	10 010	..	..	..	..
Concrete aggregate	8 793	38 446	..	..	..	..
Asphalt aggregate	6 987	30 520	..	..	..	..
Road metal	25 272	98 746	..	..	..	..
Railroad ballast	5 699	34 409	..	..	..	..
Other uses	31 514	122 654	..	..	..	..
Total	100 236	445 622	..	..	..	..

P Preliminary; .. Not available; - Nil; (n.f.) Not finished or dressed.
Figures may not add due to rounding.

TABLE 2. CANADA, PRODUCTION OF SAND AND GRAVEL BY PROVINCE, 1985-87

	1985		1986		1987P	
	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)
Newfoundland	2 568	12 589	2 343	11 112	2 650	13 250
Prince Edward Island	588	1 917	501	1 754	540	1 917
Nova Scotia	8 829	23 958	7 889	22 064	7 575	22 725
New Brunswick	9 177	X	8 972	X	9 650	X
Quebec	32 520	X	29 607	X	31 850	X
Ontario	77 796	191 690	87 515	248 233	94 500	289 170
Manitoba	12 224	33 949	13 050	35 752	13 000	36 790
Saskatchewan	11 433	28 267	14 189	31 509	13 850	29 775
Alberta	49 237	121 668	45 128	133 092	44 350	141 025
British Columbia	43 774	107 670	42 888	105 282	38 600	102 290
Yukon and Northwest Territories	7 987	11 976	5 888	16 635	3 700	11 185
Canada	256 183	609 638	257 970	605 433	260 265	648 127

P Preliminary; X Confidential.
Figures may not add due to rounding.

TABLE 3. AVAILABLE DATA ON CONSUMPTION OF SAND AND GRAVEL, BY PROVINCE, 1984 AND 1985

		Atlantic Provinces	Quebec	Ontario	Western Provinces[1]	Canada
				(000 tonnes)		
Roads	1984	13 785	24 050	37 298	76 404	151 539
	1985	15 932	19 897	42 623	86 648	165 100
Concrete aggregate	1984	1 474	3 987	12 259	9 705	27 425
	1985	1 598	4 397	15 921	11 703	33 619
Asphalt aggregate	1984	1 799	3 160	4 167	5 072	14 198
	1985	1 600	3 055	4 951	7 618	17 224
Railroad ballast	1984	126	133	584	4 021	4 864
	1985	87	442	520	4 043	5 092
Mortar sand	1984	77	338	1 107	839	2 361
	1985	80	198	1 368	427	2 073
Backfill for mines	1984	120	218	870	342	1 551
	1985	--	211	989	562	1 761
Other fill	1984	1 242	2 903	8 916	7 210	20 271
	1985	1 631	4 295	9 341	12 459	27 726
Other uses	1984	351	400	2 045	8 755	11 551
	1985	235	25	2 083	1 245	3 588
Total sand and gravel	1984	18 974	35 189	67 246	112 348	233 759
	1985	21 162	32 520	77 796	124 705	256 183

[1] The western provinces include the Yukon and Northwest Territories.
-- Amount too small to be expressed.
Figures may not add due to rounding.

TABLE 4. CANADA, EXPORTS AND IMPORTS OF SAND AND GRAVEL AND CRUSHED STONE, 1984-87

	1984		1985		1986		Jan.-Sept. 1987	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Exports								
Sand and gravel								
United States	108 926	551	234 883	921	249 566	925	287 846	1 343
South Africa	122	32	1 854	14	36	10	18	5
Algeria	146	14	-	-	-	-	-	-
France	590	12	65	11	133	46	103	64
St. Pierre and Miquelon	19	2	-	-	19	2	19	2
Other countries	6	2	4 988	33	79	14	15 273	521
Total	109 809	613	241 790	979	249 833	997	303 259	1 935
Crushed limestone								
United States	1 216 628	6 811	1 195 939	6 550	1 340 394	7 487	1 204 655	6 759
Other countries	46	4	-	-	9 951	66	-	-
Total	1 216 674	6 815	1 195 939	6 550	1 350 345	7 553	1 204 655	6 759
Imports								
Sand and gravel, n.e.s.								
United States	1 266 255	6 113	1 109 425	5 380	1 046 574	5 396	943 696	5 167
West Germany	715	3	846	3	135	2	1 537	6
Other countries	13	2	1 530	24	480	17	615	8
Total	1 266 983	6 118	1 111 801	5 408	1 047 189	5 415	945 848	5 181
Crushed limestone								
United States	1 944 045	9 666	2 071 651	10 889	2 354 276	13 095	1 962 334	9 192
Total	1 944 045	9 666	2 071 651	10 889	2 354 276	13 095	1 962 334	9 192
Crushed stone, n.e.s.								
United States	44 108	1 377	66 788	1 646	48 683	1 473	53 740	1 786
Italy	230	28	43	6	71	8	155	24
Other countries	76	2	195	38	36	5	176	44
Total	44 414	1 408	67 026	1 690	48 790	1 486	54 071	1 854

Source: Statistics Canada.
- Nil; n.e.s. Not elsewhere specified.

TABLE 5. LIGHTWEIGHT AGGREGATE PLANTS IN CANADA, 1986

Company	Location	Commodity	Remarks
Atlantic Provinces			
Annapolis Valley Peat Moss Company Limited	Berwick, N.S.	Perlite, Vermiculite	Processed mainly for use in horticulture.
Avon Aggregates Ltd.	Minto, N.B.	Expanded Shale	Processed for concrete products industry.
Quebec			
Armstrong World Industries Canada Ltd.	Gatineau	Perlite	Processed for use in ceiling tile manufacture.
Domtar Inc.	Montreal	Perlite, Vermiculite	Processed material purchased for use in gypsum plaster and wallboard at all company plants.
Miron Inc.	Montreal	Pumice	Purchased for concrete block manufacture.
Perlite Industries Inc.	Ville Saint-Pierre	Perlite	Processed for use in horticulture and as industrial filler.
V.I.L. Vermiculite Inc.	Lachine	Vermiculite	Processed for use in horticulture and as loose insulation.
Ontario			
Canadian Gypsum Company, Limited	Hagersville	Perlite	Processed for use in gypsum plaster.
National Slag Limited	Hamilton	Slag	Used in concrete blocks and as slag cement.
W.R. Grace & Co. of Canada Ltd.	St. Thomas	Vermiculite	Vermiculite processed for use in horticulture and as loose insulation.
	Ajax	Vermiculite, Perlite	Perlite processed for use in gypsum plaster and in horticulture.
Prairie Provinces			
Apex Aggregate	Saskatoon, Sask.	Expanded clay	Processed for concrete block manufacture.
Cindercrete Products Limited	Regina, Sask.	Expanded clay	Processed for concrete products industry.
Consolidated Concrete Limited	Calgary, Alta.	Expanded shale	Processed for concrete products industry.
	St. Albert, Alta.	Expanded clay	Processed for concrete products industry.
CBR Cement Canada Limited	Edmonton, Alta.	Expanded clay	Processed for concrete block manufacture.
Kildonan Concrete Products Ltd.	Winnipeg, Man.	Expanded clay	Processed for concrete products industry.
W.R. Grace & Co. of Canada Ltd.	Winnipeg, Man.	Vermiculite, Perlite	Perlite processed for use in gypsum plaster and in horticulture.
	Edmonton, Alta.	Vermiculite, Perlite	Vermiculite processed for use in horticulture and as loose insulation.
British Columbia			
Ocean Construction Supplies Limited	Vancouver	Pumice	Purchased for concrete block manufacture.
Aurun Mines Ltd.	Surrey	Perlite	Integrated mine, process and marketing.

TABLE 6. CANADA, IMPORTED RAW MATERIALS PURCHASED, 1985 AND 1986

	1985		1986	
	(tonnes)	($)	(tonnes)	($)
Pumice, perlite and vermiculite[1]	35 399	4 715 061	45 468	5 756 367

Source: Company data.
[1] Combined to avoid disclosing confidential company data.

TABLE 7. CANADA, PRODUCTION OF LIGHTWEIGHT AGGREGATES, 1985 AND 1986

	1985		1986	
	(m^3)	($)	(m^3)	($)
From domestic raw materials				
Expanded clay, shale and slag	193 578	5 323 452	246 159	7 061 929
From imported crude materials				
Expanded perlite and exfoliated vermiculite[1]	310 837	11 915 071	322 245	12 798 396
Total	504 415	17 238 523	568 404	19 860 325

Source: Company data.
[1] Combined to avoid disclosing confidential company data.

TABLE 8. CANADA, CONSUMPTION OF SLAG, PERCENTAGE BY USE, 1984-86

Use	1984	1985	1986
Concrete block manufacture	28.0	28.0	29.0
Ready-mix concrete	1.0	1.0	3.0
Loose insulation	1.0	1.0	1.0
Slag cement	70.0	70.0	67.0

Source: Company data.

TABLE 9. CANADA, CONSUMPTION OF EXPANDED CLAY AND SHALE, PERCENTAGE BY USE, 1984-86

Use	1984	1985	1986
Concrete block manufacture	80.5	78.2	79.8
Precast concrete manufacture	7.1	5.1	6.7
Ready-mix concrete	7.2	12.0	7.3
Horticulture and miscellaneous uses	5.2	4.7	6.2

Source: Company data.

TABLE 10. CANADA, CONSUMPTION OF EXPANDED PERLITE, PERCENTAGE BY USE, 1984-86

Use	1984	1985	1986
Insulation			
in gypsum products	26.7	31.6	14.4
in other construction materials	27.1	37.7	33.3
Horticulture and agriculture	38.4	25.7	36.6
Loose insulation and miscellaneous uses	7.8	5.0	15.7

Source: Company data.

TABLE 11. CANADA, CONSUMPTION OF EXFOLIATED VERMICULITE, PERCENTAGE BY USE, 1984-86

Use	1984	1985	1986
Insulation			
loose	24.5	23.9	21.6
in concrete and concrete products	1.2	-	-
in gypsum products	0.7	-	-
Horticulture	56.7	64.3	53.5
Miscellaneous uses	16.9	11.8	24.9

Source: Company data.
- Nil.

TABLE 12. CANADA, VALUE OF CONSTRUCTION[1] BY TYPE, 1985-87

	1985	1986	1987
		($ millions)	
Building Construction			
Residential	24 145	28 637	29 281
Industrial	3 470	3 129	2 996
Commercial	8 697	9 865	10 744
Institutional	3 119	3 488	3 697
Other building	2 028	1 883	1 972
Total	41 459	47 002	48 690
Engineering Construction			
Marine	379	387	473
Highways, airport runways	5 179	5 029	5 216
Waterworks, sewage systems	2 481	2 258	2 488
Dams, irrigation	283	272	273
Electric power	3 314	3 649	3 964
Railway, telephones	2 787	2 627	2 903
Gas and oil facilities	9 207	6 638	5 683
Other engineering	2 894	2 544	2 658
Total	26 524	23 404	23 658
Total construction	67 983	70 406	72 348

Source: Statistics Canada.
[1] Actual expenditures 1985, preliminary actual 1986, intentions 1987.

TABLE 13. CANADA, VALUE OF CONSTRUCTION[1] BY PROVINCE, 1985-87

	1985			1986			1987		
	Building Construction	Engineering Construction	Total	Building Construction	Engineering Construction	Total	Building Construction	Engineering Construction	Total
					($000)				
Newfoundland	686 110	1 038 241	1 724 351	808 806	719 888	1 528 694	833 741	604 261	1 438 002
Nova Scotia	1 322 732	1 026 096	2 348 828	1 444 845	828 860	2 273 705	1 500 734	732 121	2 233 055
New Brunswick	995 075	452 480	1 447 555	1 040 536	404 255	1 444 791	1 086 815	464 899	1 551 714
Prince Edward Island	181 128	63 494	244 622	221 222	65 319	286 541	207 931	76 574	284 505
Quebec	10 245 635	4 170 063	14 415 698	11 477 930	4 097 549	15 575 479	11 721 159	4 334 030	16 055 189
Ontario	15 858 300	5 250 869	21 109 169	19 361 442	5 407 360	24 768 802	20 446 162	5 908 798	26 354 960
Manitoba	1 607 763	820 117	2 427 880	1 849 696	895 268	2 744 964	1 802 815	1 047 739	2 850 554
Saskatchewan	1 528 847	1 744 874	3 273 721	1 568 662	1 312 843	2 881 505	1 637 169	1 406 674	3 043 843
Alberta	3 888 425	7 387 129	11 275 554	4 024 940	6 078 331	10 103 271	4 210 469	5 899 695	10 110 164
British Columbia, Yukon and Northwest Territories	5 144 972	4 570 814	9 715 786	5 203 520	3 594 742	8 798 262	5 242 760	3 182 774	8 425 534
Canada	41 458 987	26 524 177	67 983 164	47 001 599	23 404 415	70 406 014	48 689 955	23 657 565	72 347 520

Source: Statistics Canada.

[1] Actual expenditures 1985, preliminary actual 1986, intentions 1987.

Molybdenum

D.G. FONG

Molybdenum production in the western world was 71 175 t in 1987, a decline of 8%. The reduction was due to a large production cutback by the primary producers, offset partly by an increase in output by the by-product producers in the United States.

The consumption of molybdenum, estimated at 74 800 t, was unchanged from 1986. A strong performance by the steel industry, especially the stainless steel sector, helped to sustain demand. Towards year-end, reports of an upward trend in capital spending implied higher consumption in the coming year.

Molybdenum prices fluctuated during the year. The prospect of increased by-product supplies because of a stronger copper market, large stocks overhanging the market and the uncertain supply situation at mid-year because of a severe winter in Chile provided the impetus for the price swings. Molybdenum prices could improve marginally in 1988 but there is unlikely to be a major increase; high inventories and excess capacity will continue to be the main stumbling blocks for a major market recovery.

Canadian molybdenum production increased by 7% from 1986. The large increase at the Endako mine, which operated for the whole year following its reopening during the second half of 1986, was partly offset by lower output from by-product producers. Production from Endako is expected to increase further in 1988. However, this will not raise annual Canadian production because of an expected decline in activities at by-product operations.

CANADIAN DEVELOPMENTS

Placer Dome Inc. was incorporated through the merger of three major Canadian mining companies: Placer Development Limited, Dome Mines, Limited and Campbell Red Lake Mines Limited. The merger, which became effective August 13, 1987, makes Placer Dome the largest gold mining company in North America. The company is also a significant producer of molybdenum, copper, silver and natural gas.

In 1987, Placer Dome produced about 3 400 t of molybdenum contained in concentrate from its Endako mine in British Columbia. This was up from 1 022 t a year earlier. Late in 1987, the company announced plans to further increase its annual output to 4 536 t in 1988. Since its reopening in June 1986, Endako has been striving to make it the lowest cost primary molybdenum mine in the western world. A significant reduction in operating costs was made possible through the purchase of surplus power from the British Coumbia government and the decertification of its labour unions.

The Endako operation has also obtained profitable results from its molybdenum upgrading facilities. These include two roasters, with a capacity of 10 800 t/y, and a high purity lubricant grade molybdenum plant, which are located at the mine-site. Endako also produces chemical and catalyst grade molybdenum products on a toll basis in a leaching plant at Equity Silver Mines Limited, a subsidiary of Placer Dome.

Brenda Mines Ltd. continued to operate at a high level, producing about 4 350 t of molybdenum in 1987. At its current rate of operation, ores at the present pit are expected to be depleted in mid-1990.

Hemlo Gold Mines Inc. was reported to be near a decision at year-end on selecting a process that it will use to remove impurities from its molybdenum concentrate. The Hemlo gold deposit has 0.16% molybdenum, but it also contains arsenic, antimony and mercury. The company said it will choose between controlled roasting and leaching to remove the impurities from the molybdenum concentrate. When the recovery circuit is fully operational in 1989, it could produce between 1 000 and 1 500 t/y at capacity. Hemlo Gold is 51% owned by Noranda Inc.

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In September, Lornex Mining Corporation Ltd., Cominco Ltd., and Highmont Mining Corporation reached a tentative agreement to include the Highmont property in the Highland Valley Copper partnership. Under the agreement, Cominco will own 50%, Lornex 45% and Highmont 5%. Lornex will provide the partnership with $16.7 million in cash to retain its 45% equity. The Highmont mine was closed in 1984, after three years of operation, due to depressed markets for copper and molybdenum.

Cominco and Lornex formed the Highland Valley Copper partnership in 1986 to manage their combined assets in the Highland Valley of British Columbia. Mining is to be gradually shifted from the Lornex pit to the Cominco pit, while milling will continue at the Lornex and Bethlehem (Cominco) mills. The takeover of Cominco by Teck Corporation in late 1986 facilitated the negotiation for adding Highmont to the partnership. Highmont is owned 50% by Teck Corp.

The daily throughput at the Lornex and Cominco mills was expanded from 111 584 t/d to 125 000 t/d at year-end, which was due mainly to the softer ore at the Cominco pit. Despite the mill rate expansion, molybdenum production is expected to be less because the Cominco ore has a lower molybdenum grade.

WORLD DEVELOPMENTS

The major primary producers in the United States continued to trim their output during the second half of 1987 in order to stabilize the falling market price. Beginning in August, AMAX Inc. made production cuts at its Henderson mine, in addition to the indefinite closure at its Climax mine in March. As a result, the company produced only 12 470 t of molybdenum in 1987, a reduction of 8 074 t from 1986.

Cyprus Minerals Company also decided to reduce molybdenum output from its Thompson Creek mine from 3 175 t/y to 1 587 t/y, effective at the end of August. Thompson Creek produced 6 620 t of molybdenum in 1986.

The production cutback at Thompson Creek did not have a major impact on Cyprus Minerals' total molybdenum output in 1987. The lower output was partly offset by an increase in by-product production at its Sierrita mine because of the strong copper market. In addition to Sierrita and Thompson Creek, Cyprus Minerals also operated the Bagdad copper-molybdenum mine, which produced 2 720 t of molybdenum in 1987. Thus, the total Cyprus Minerals molybdenum output for 1987 was about 13 150 t.

At the Bingham, Utah, mine of Kennecott Corporation, the US$400 million modernization program was reported to be on schedule, with the renovation expected to be completed by late 1988. The mine is expected to produce 5 440 t/y of by-product molybdenum at full capacity. With a limited mining operation in 1987, Bingham produced about 1 810 t, which is expected to be doubled in 1988.

The People's Republic of China has gained a small but important foothold in the world molybdenum market during the last two years. It has established regular sales in the Eastern Bloc countries in addition to those in the western world. China's market gains are mainly at the expense of the primary producers in the western world. Shipments from China in 1987 were less reliable, due largely to a shortage of hydroelectric power in that country.

At Corporacion Nacional del Cobre de Chile (CODELCO-CHILE), shipments of molybdenum were temporarily disrupted during the third quarter because of major snow storms and a one-month shutdown for refurbishing the Chuquicamata roaster. Despite these disruptions, total molybdenum production from CODELCO remained at about 16 780 t.

The stoppage at the Chuquicamata roaster was to install an auxiliary unit that will bring the plant up to designed capacity. The roaster, a 12-section Herreshoff furnace, was to have produced 10 900 t/y of molybdenum oxide, but it has been operating at only 8 600 t since its startup in 1982.

The United States Trade Representative (USTR) rejected a petition by Molibdenos y Metales S.A. (Molymet) of Chile to grant duty-free status for ferromolybdenum imports under the Generalized System of Preferences (GSP). The USTR rejected the Molymet request because of low capacity utilization and financial difficulties facing the U.S. molybdenum industry.

President Reagan decided at year-end to remove molybdenum concentrates, ores and oxides from the GSP program. As a result of this action, developing countries that export molybdenum to the United States will no longer have duty-free status under the GSP. Chile, Mexico and Peru had been the main beneficiaries. These products were removed from the program after the Administration determined that the exporting countries no longer needed GSP treatment to be competitive in world markets, and that GSP treatment to these exporters was injurious to U.S. producers. President Reagan made the decision in response to a petition filed on behalf of the U.S. industry by the Cyprus Minerals Company.

USES

Molybdenum is used in a wide range of products as an alloy additive, a chemical compound, a pure metal and as a lubricant. Approximately 90% of all molybdenum consumed in the western world is used in metallurgical applications including steel, ferrous castings, special alloys, and pure molybdenum metal. The remaining 10% is used in non-metallurgical applications such as chemicals, catalysts and lubricants.

As an alloying additive in steel, molybdenum imparts hardenability, strength, toughness and resistance to corrosion and abrasion. Tool steels, stainless steels, high-strength steels, heat resisting steels and a wide range of alloy steels are important consumers of molybdenum. Depending on type and specification, molybdenum is added in amounts ranging from less than 0.1% to nearly 10%. Molybdenum can be added as a sole agent but, more often, it is used in combination with other additive metals.

Molybdenum is an important alloying element in most types of tool steels. Among the tool steel additives, molybdenum and tungsten both promote red hardness and increase wear resistance in high speed steels. The performance of these steels is proportional to the percentage of the elements. However, molybdenum produces more carbide than tungsten per unit weight added, and thus can replace tungsten at a rate of almost one to two. For some hot work tool steels and high speed steels, the molybdenum content can be as high as 10%.

Additions of molybdenum to austenitic and ferritic stainless steels enhance resistance to corrosive acids and brines. These steels are finding increasing use in heat exchangers for severe chemical environments, seawater condenser tubings, caustic evaporators, and heat resisting steels operating under stress and high temperatures.

In high-strength-low-alloy steels, the addition of molybdenum increases the yield and tensile strength, and improves toughness and weldability. Steels with these properties are especially useful in structural applications and in Arctic-grade large-diameter pipelines. The consumption intensity of molybdenum in pipeline steels has declined, especially in Japan and western Europe where pipeline manufacturers have switched to non-molybdenum steels, even for the Arctic-grade pipelines. This increase in substitution to other ferroalloy additives was brought about mainly by the high prices and short supply of molybdenum in the late 1970s.

Molybdenum is an important constituent of many high performance alloys that are extremely resistant to heat, corrosion and wear. These alloys are used extensively in aerospace components, chemical processing plants, and high temperature furnace and foundry parts.

Molybdenum compounds are used as catalysts in the petroleum refining and chemical processing industries. Molybdenum orange, an important molybdenum pigment, is used in printing inks, dyes and corrosion resistant primers. Pure molybdenum disulphide is an excellent dry lubricant and is used as an oil additive. The lamellar structure of molybdenum disulphide helps reduce friction and thus prolongs engine life. In recent years, non-metallurgical applications have been experiencing a faster growth rate than other uses.

New uses have recently been developed for molybdenum in a new generation of batteries. The lithium-molybdenum battery is found to have more energy and power per cell volume than the conventional nickel-cadmium or alkaline units. It is also superior in terms of rechargeability, charge retention and storage temperature range. Because of the relatively high price, its main market is expected to be original equipment manufacturers, which install batteries in such items as cameras, photoflashes, portable televisions and computers, military communications equipment and any other applications where light weight, charge retention and power density are important factors.

PRICES

The producers' list price started the year at US$7.61/kg for canned molybdenum oxide. Both AMAX Inc. and Cyprus Minerals

Company, the two U.S. primary producers, held prices at that level until May when excess supply and weak demand caused them to lower their prices to US$7.16.

Dealers continued to lower their prices throughout the first half of 1987, thereby increasing the price spread between them and producers. They also were accumulating stocks that, together with the downward adjustment in price by the U.S. primary producers, caused the dealers' market price to drop to a low of US$5.56 in July. This market began to rally in August as a result of shipping disruptions in Chile and the scrambling of a number of traders to cover their short positions in the market. Towards year-end, the dealers' market began to stabilize at about US$6.72/kg.

OUTLOOK

Following the re-establishment of a producer price by the primary producers in the United States two years ago, it appeared as if molybdenum was destined for a managed and stable market. However, developments during 1987 have changed the underlying assumptions and will make it difficult to maintain market stability. Among the important factors are the significant loss of market share by the primary producers, the increasing dominance by the by-product producers as a result of the strong copper market, the reported price discounting, and the establishment of China as an important supplier. This situation is expected to continue in 1988 and, quite likely, the year after.

Western world mine output in 1988 is expected to fall short of consumption by some 4 500 t due to the cutback by U.S. primary producers. This deficit will be offset by a corresponding reduction in stocks, the first major reversal in stock trends since 1984.

In terms of consumption, 1988 is forecasted to be better than 1987. As the world economic recovery advances into a late stage, an increase in investments is expected for capital goods. The demand for tool and alloy steels was already showing signs of recovery in the second half of 1987, especially in the construction, machinery, automobile and oil and gas sectors. Although stainless steel is not as prominent a market for molybdenum as tool and alloy steels, it is still an important user. The stainless steel market is projected to continue at a strong, but declining, pace throughout 1988.

The price of molybdenum might rise slightly during the next year but no major increase is expected because a large capacity is ready to be brought back on-stream whenever there is a clear signal of higher prices.

The production of molybdenum in Canada in 1988 is forecasted to remain at the 1987 level, taking into account the planned increase in primary producer output and reductions by the by-product producers. However, Canadian supply could increase substantially by 1989, when the molybdenum circuit of the Hemlo Gold mine is brought on-stream.

Free trade with the United States could create an additional market opportunity for Canadian molybdenum in the long term. Presently, all molybdenum products entering the United States are subject to duty. The removal of the U.S. duty should allow Canadian producers to have equal access and compete on an equal footing with their U.S. competitors.

Canadian molybdenum producers have taken steps in recent years to significantly improve their competitiveness. This was accomplished mainly through cost-cutting measures such as lower employment costs, higher productivity, and negotiations for lower hydropower rates. These changes have placed Canadian producers among the lowest cost operations in the western world, thus enabling them to survive the current market depression.

PRICES

Prices in US$ per kilogram of contained molybdenum, f.o.b. shipping point unless otherwise indicated, December 31.

	1986	1987
	($)	
By-product concentrates (MoS_2)	6.17-6.28	5.18-5.40
Molybic oxide (MoO_3) in cans, producer list price[1]	7.16	7.16
Dealer oxide (MoO_3) in cans, min. 57% Mo	6.81-7.05	6.57-6.72
Ferromolybdenum[2] dealer export (f.a.s. port)	8.05-8.16	8.66-8.82

Source: Metals Week.

[1] Price quotation of AMAX Inc. and Cyprus Minerals Company. [2] Price based on molybdenum content.

f.a.s. Free alongside ship; f.o.b. Free on board.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
CANADA					
32900-1	Molybdenum ores and concentrates	free	free	free	free
33505-1	Molybdenum oxides	10.0	12.5	25.0	8.0
35120-1	Molybdenum metal in powder, pellets, scrap, ingots, sheets, strips, plates, bars, rods, tubing or wire, for use in Canadian manufactures	free	free	25.0	free
37506-1	Ferromolybdenum	free	4.0	5.0	free
92847-1	Molybdates	9.2	9.2	25.0	6.0
	Temporary reduction, June 3, 1980 to June 30, 1987	free			free
92856-1	Molybdenum carbides	free	free	25.0	free
	Temporary reduction, June 3, 1980 to December 31, 1987	free			free
UNITED STATES					
417.28	Ammonium molybdate		4.3		
418.26	Calcium molybdate		4.7		
419.60	Molybdenum compounds		3.2		
421.10	Sodium molybdate		3.7		
423.88	Mixtures of two or more inorganic compounds: in chief value of molybdenum, molybdenum content		2.8		
601.33	Molybdenum ore (per lb. on Mo content)		9.0¢		
606.31	Ferromolybdenum		4.5		
628.70	Molybdenum metal, waste and scrap		6.0		
628.72	Molybdenum metal, unwrought (per lb. on Mo content)		6.3¢		
628.74	Molybdenum metal, wrought		6.6		

EUROPEAN ECONOMIC COMMUNITY (MFN)		1987	Base Rate	Concession Rate
			(%)	
26.01	Molybdenum ores and concentrates	free		
28.28	Molybdenum oxides and hydroxides	5.3	8.0	5.3
28.47	Molybdates	6.6	11.2	6.6
28.56	Molybdenum carbides	8.0	9.6	8.0
73.02	Ferromolybdenum	4.9	7.0	4.9
81.02	Molybdenum, unwrought or wrought, and articles thereof:			
	A. Unwrought (including bars not further prepared than sintered and powders); waste and scrap:			
	I. Powders	–		
	II. Other	5		
	B. Bars (other than bars not further prepared than sintered), rods, angles, shapes, sections, wire, filaments, plates, sheets, strip and foil	8		
	C. Other	10		
JAPAN (MFN)				
26.01	Molybdenum ores and concentrates			
	A. Quota	free		
	B. Other	free	7.5	free
28.28	Molybdenum trioxide	3.7	5.0	3.7
28.47	Molybdates	4.9	7.5	4.9
28.56	Molybdenum carbides	3.7	5.0	3.7
73.02	Ferromolybdenum	4.9	7.5	4.9
81.02	Molybdenum metal			
	A. Unwrought, powders and flakes	3.7	5.0	3.7
	B. Waste and scrap	3.7	5.0	3.7
	C. Other	4.9	7.5	4.9

Sources: The Customs Tariff, 1987, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1987), USITC Publication 1910; U.S. Federal Register, Vol. 44, No. 241; Official Journal of the European Communities, Vol. 29, No. L335, 1987; Customs Tariff Schedules of Japan, 1987.

TABLE 1. CANADA, MOLYBDENUM PRODUCTION AND TRADE, 1985-87, AND CONSUMPTION, 1984-86

	1985		1986		1987P	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Production (shipments)[1]						
British Columbia	7 526	71 099	10 896	87 722	11 581	92 648
Quebec	326	3 260	355	2 389	-	-
Total	7 852	74 359	11 251	90 111	11 581	92 648
					(Jan.-Sept.)	
Exports						
Molybdenum in ores, concentrates and scrap[2]						
Belgium-Luxembourg	1 208	9 732	4 346	36 701	3 605	29 208
Japan	1 004	10 964	2 139	20 201	2 494	22 976
Netherlands	766	6 634	920	7 196	1 452	13 142
United States	470	4 392	717	7 290	1 020	10 614
United Kingdom	547	4 971	997	7 946	523	3 699
Chile	547	5 432	573	4 164	613	3 459
France	0	0	458	3 827	324	2 697
West Germany	1 015	6 457	1 100	6 345	399	2 532
Australia	25	451	32	444	59	657
South Korea	55	512	85	605	60	367
Sweden	0	0	0	0	31	201
Iceland	0	0	0	0	36	181
Total	5 637	49 546	11 367	94 719	10 616	89 733
Imports						
Molybdic oxide and hydroxides	187	1 878	203	2 001	145	1 497
Molybdenum in ores and concentrates (Mo content)	577	4 517	1 079	7 654	..	..
Ferromolybdenum alloys	274	2 796	348	2 939	..	..

	1984[5]	1985[5]	1986P
		(kilograms)	
Consumption[3] (Mo content)			
Carbon steel	..	..	59 845
Stainless steel	..	..	150 444
Other steel	..	..	375 232
Cast iron	..	..	33 093
Other uses[4]	..	..	65 429
Total	736 664	772 301	684 043

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Producers' shipments (Mo content of molybdenum concentrates, molybdic oxide and ferromolybdenum). [2] Ores and concentrates category includes molybdenite and molybdic oxide. [3] Available data, as reported by consumers. [4] Nonferrous alloys, electrical, pigments and other uses. [5] Comparable consumption detail not available prior to 1986.

P Preliminary; .. Not available; - Nil.

TABLE 2. CANADA, MOLYBDENUM PRODUCTION, TRADE AND CONSUMPTION, 1970, 1975 AND 1978-87

			Imports		
	Production[1]	Exports[2]	Molybdic oxide[3]	Ferro-molybdenum[4]	Consumption[5]
			(kilograms)		
1970	15 318 593	13 763 800	33 500	29 619	1 036 940
1975	13 323 144	15 710 300	56 400	269 281	1 436 883
1978	13 943 405	13 421 000	329 500	55 294	1 268 640
1979	11 174 586	11 481 900	335 900	153 945	1 249 944
1980	11 889 000	14 584 500	361 700	53 618	1 055 107
1981	12 850 000	13 664 000	423 000	36 069	1 314 584
1982	13 961 000	17 444 000	193 000	6 840	672 118
1983	10 194 000	11 284 000	141 000	34 000	555 167
1984	11 556 777	8 896 000	238 000	186 000	736 664
1985	7 852 060	5 637 000	187 000	274 076	772 301
1986	11 250 625	11 367 000	203 000	347 784	684 043
1987P	11 581 000	..	..	..	..

Sources: Energy, Mines and Resources Canada; Statistics Canada; except where noted.
[1] Producers' shipments (Mo content of molybdenum concentrates, oxide and ferromolybdenum).
[2] Mo content, oxides, ores and concentrates. [3] Gross weight. [4] 1970-82 United States exports to Canada, reported by the U.S. Bureau of Commerce, Exports of Domestic and Foreign Merchandise (Report 410), over 50% molybdenum; 1983-87 Statistics Canada. [5] Mo content of molybdenum products reported by consumers.
P Preliminary; .. Not available.

TABLE 3. WORLD PRODUCTION OF MOLYBDENUM IN ORES AND CONCENTRATES, 1985-87

Country	1985	1986	1987P
	(tonnes Mo content)		
United States	48 988	40 315	34 290
Canada	7 188	12 226	13 110
Chile	18 400	16 581	16 780
U.S.S.R.e	11 200	11 200	11 200
People's Republic of Chinae	6 800	9 070	7 257
Peru	3 673	3 800	2 540
Mexico	3 761	3 390	3 130
Mongoliae	1 000	1 000	1 000
Iran	1 000	1 000	1 000
Republic of Koreae	300	225	225
Japane	120	100	100
Finlande	330	300	300
Total	102 760	99 207	90 932

Sources: Energy, Mines and Resources Canada; U.S. Bureau of Mines, Minerals Yearbook, Preprint, 1986; U.S. Bureau of Mines, Mineral Commodity Summaries, 1987; Intermet Molybdenum Database, 1987, Santiago, Chile; Noranda Inc.
e Estimated; P Preliminary.

TABLE 4. PRINCIPAL MOLYBDENUM PRODUCERS IN THE WESTERN WORLD, 1987

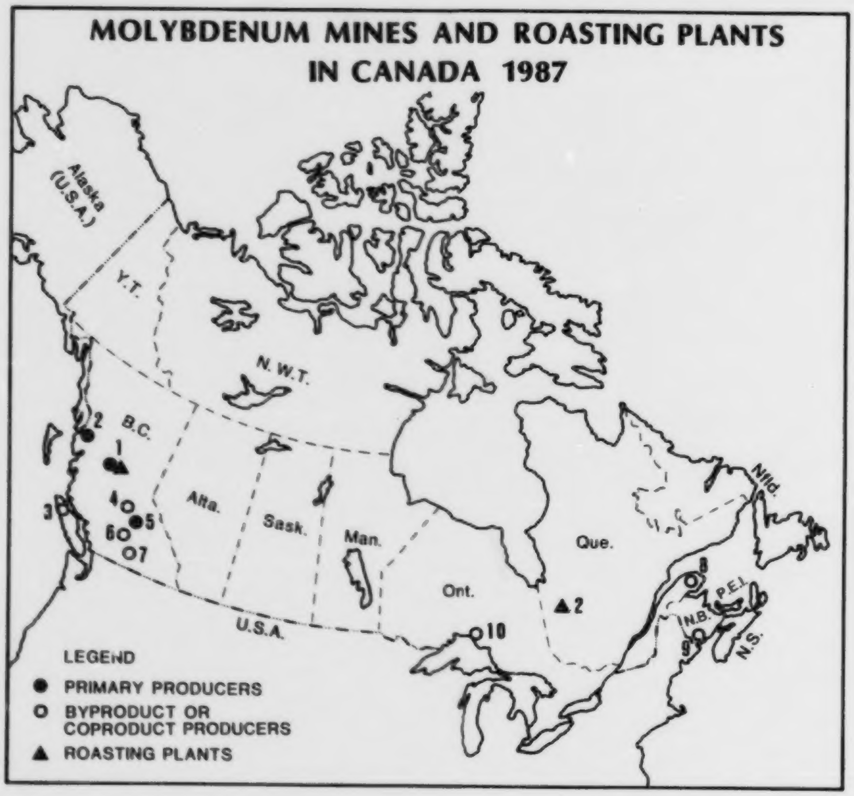
Company	Country	Mine ProductionP
		(t/y Mo)
AMAX Inc.	United States	12 470
Corporacion Nacional del Cobre de Chile (CODELCO-CHILE)	Chile	16 780
Cyprus Minerals Company	United States	13 150
Noranda Inc.	Canada	4 350
Placer Dome Inc.	Canada	4 310
Lornex Mining Corporation Ltd.	Canada	2 770
Mexicana de Cobre S.A.	Mexico	3 130
Kennecott Minerals Company	United States	1 810
Southern Peru Copper Corporation (SPCC)	Peru	2 540
Newmont Mining Corporation	United States	2 310
Montana Resources Inc.	United States	3 630
BHP-Utah Mines Ltd.	Canada	1 680
Phelps Dodge Corporation	United States	907
Total		69 837

P Preliminary.

TABLE 5. CANADA, MINE PRODUCTION, 1986

Company and Mine Name	Location	Type of Producer	Mill Capacity (t/d)	Ore Milled		Concentrates Produced		
				Tonnes	Grade (% Mo)	Tonnes	Grade (% Mo)	Contained Mo (tonnes)
Amax of Canada Limited, Kitsault mine	Alice Arm, B.C.	Primary	10 886	-	-	-	-	-
Brenda Mines Ltd.	Peachland, B.C.	Coproduct	27 200	10 203 918	0.048	7 864	55.38	4 355
Gibraltar Mines Limited	McLeese Lake, B.C.	By-product	37 195	12 182 584	0.010	1 062	52.55	558
Golden Giant Mines Ltd.	Hemlo, Ont.	By-product	3 000	-	-	-	-	-
Highland Valley Copper	Highland Valley, B.C.	By-product	111 584	20 508 290	0.016	3 716	54.99	2 043
Highmont Mining Corporation	Highland Valley, B.C.	Coproduct	22 680	-	-	-	-	-
Lornex Mining Corporation Ltd.[1]	Highland Valley, B.C.	By-product	72 575	14 463 316	0.017	3 490	54.82	1 913
Mount Pleasant Tungsten Mine	Charlotte County, N.B.	Coproduct	2 000	-	-	-	-	-
Noranda Inc., Boss Mountain Division	Williams Lake, B.C.	Primary	2 631	-	-	-	-	-
Mines Gaspé Division Needle Mountain and Copper Mountain mines	Holland Township Gaspé, Que.	By-product	32 800	1 178 988	0.048	667	53.22	355
Placer Development Limited,[2] Endako mine	Endako, B.C.	Primary	29 937	1 466 011	0.088	1 928	53.00	1 022
Utah Mines Ltd.[3] Island Copper mine	Port Hardy, B.C.	By-product	46 502	17 484 419	0.015	4 217	46.96	1 980
Total								12 226

Sources: Energy, Mines and Resources Canada; Company annual reports.
[1] Formed a partnership, Highland Valley Copper, with Cominco Ltd. in 1986; [2] Amalgamated with Dome Mines, Limited and Campbell Red Lake Mines Limited to form Placer Dome Inc. in 1987; [3] Name changed in 1987 to BHP-Utah Mines Ltd.
- Nil.



MOLYBDENUM MINES AND ROASTING PLANTS IN CANADA 1987

Alaska (U.S.A.)
Y.T.
N.W.T.
B.C.
Alta.
Sask.
Man.
Ont.
Que.
Nfld.
P.E.I.
N.B.
N.S.
U.S.A.
1
2
3
4
5
6
7
8
9
10
▲2
LEGEND
● PRIMARY PRODUCERS
○ BYPRODUCT OR COPRODUCT PRODUCERS
▲ ROASTING PLANTS

Mines

1. Placer Dome Inc. (Endako mine)
2. Amax of Canada Limited (Kitsault mine)
3. BHP-Utah Mines Ltd. (Island Copper mine)
4. Gibraltar Mines Limited
5. Noranda Inc. (Boss Mountain Division)
6. Highland Valley Copper (Lornex and Cominco partnership)
   Highmont Mining Corporation
7. Brenda Mines Ltd.
8. Noranda Inc. (Gaspé Division)
9. Mount Pleasant Tungsten Mine
10. Hemlo Gold Mines Inc. (Golden Giant mine)

Roasting Plants

1. Placer Dome Inc. (Endako mine)
2. Eldorado Gold Mines Inc. (Duparquet)

Nepheline Syenite and Feldspar

M.A. BOUCHER

SUMMARY

The glass container industry is the major consumer of nepheline syenite and feldspar in North America. Again, in 1987, strong competition from plastics, aluminum and paper continued. For this reason consumption of nepheline syenite by the glass container industry in Canada, did not improve, although the introduction of "Cooler drinks" helped sales.

Demand for fillers and extenders was reported very strong but tonnages are still very small. Consumption by the fiberglass industry was good as a result of strong activity in the construction industry, especially in Ontario but also in Quebec. Demand for ceramic grade was reported to be flat.

Published prices remained the same as in 1986.

CANADIAN DEVELOPMENTS

Production

Nepheline syenite is produced in Ontario by Indusmin, a division of Falconbridge Limited. The company operates two mines and two concentrating plants with an estimated combined production capacity of 800 000 t/y of finished products. Nepheline syenite is mined from two adjacent deposits located on Blue Mountain in Methuen Township, Peterborough County, 175 km northeast of Toronto. Preliminary figures indicate that shipments in 1987 were close to 500 000 t; this compares with 467 000 t in 1986. The nepheline syenite is upgraded to low-iron and high-iron glass grades, and to ceramic grades by primary and secondary crushing, drying, screening, high-intensity magnetic separation and pebble milling. For ultrafine grades (for use as filler in paints, plastics, etc.), the process uses air classification.

Feldspar is not produced on a large commercial scale in Canada. However, a potential producer is Bearcat Explorations Ltd. of Calgary.

Bearcat Explorations Ltd. is developing a pegmatite in southeastern British Columbia for the production of several industrial minerals. The objective is to produce a feldspathic product suitable for the glass, fiberglass and ceramic industry. Mica will be supplied to the drywall cement, paint and drilling mud industry, while quartz could be used in glassmaking and other applications.

Market studies have been conducted and a feasibility study is proposed for open-pit mining and strip mining. Production capacity of the plant still remains to be determined.

Tantalum Mining Corporation of Canada Limited (TANCO) of Bernic Lake, Manitoba reported that it was continuing to investigate the possibility of recovering feldspar as a by-product of its spodumene operation. The feldspar which is rich in rubidium (1.3 % Rb_2O) and high in potassium (9.5% K_2O) would be particularly in demand for the manufacture of high-voltage electrical insulators that require 15 to 50% K-feldspar by weight, but also for glass and other ceramic products. Some 27 000 t of feldspar could be produced annually. A $1.1 million capital expenditure on grinding equipment is planned for 1988.

CONSUMPTION

The primary glass and containers industries account for some 60% of nepheline syenite consumption in Canada, while insulation and ceramic products account for about 17% each.

Consumption of nepheline syenite in Canada by glass producers continued to be negatively influenced mainly by the use of metal but also plastics and paper, by increased recycling of glass waste, and by the development of thinner glass containers.

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Although growth in filler and extender pigment applications is expected to continue at an increasing rate, tonnages of nepheline syenite consumption will remain small for many years.

On the positive side studies are under way in the United States to investigate the use of nepheline syenite in flat glass manufacturing. Such a development, if successful would stimulate consumption of nepheline syenite.

The major consumers of nepheline syenite in Canada are: Domglas Inc., Consumers Packaging Inc., Fiberglas Canada Inc., American Standard Inc., and Crane Canada Inc.

Important consumers of feldspar are: Crane Canada Inc.; Electro Porcelain Co. Ltd.; Hamilton Porcelains Limited; J M Asbestos Inc.; and Cegelec Industrie Inc.

TRADE

Exports of nepheline syenite have declined considerably since the early 1980s.

In 1980 and 1981 total exports averaged 462 000 t; of this amount 400 000 t (86%) went to the United States.

In 1986 and 1987 (based on 9 months) exports should average 342 000 t, or a loss of 120 000 t in half a decade.

The United States remains our largest market accounting for approximately 90% of our trade.

Market areas for North American producers of feldspar, nepheline syenite and aplite

Market area	Material
Central and eastern Canada and north central United States	nepheline syenite
Northeast United States	feldspar
East central United States	aplite
Southeast and south central United States	feldspar
Southwest United States	feldspar-silica sand, feldspar

PRICES

The unit value of production (shipments) of nepheline syenite increased 6% in 1987 over 1986 and the unit value of exports to our major market, the United States dropped by 1% (based on nine-month figures).

Listed prices for nepheline syenite in 1987 remained the same as in 1986 and ranged from a low of US$23.69/t for glass grade to a high of US$109.10/t for filler and extender grades.

USES

Nepheline syenite is preferred to feldspar as a source of alumina and alkalis for glass manufacture. Its use results in more rapid melting of the batch at lower temperatures than with feldspar, thus reducing fuel consumption, lengthening the life of furnace refractories, and improving the yield and quality of glass. Other industrial uses for nepheline syenite include ceramic glazes, enamels, fiberglass and fillers in paints, papers, plastics and foam rubber.

Feldspar is the name of a group of minerals consisting of aluminum silicates of potassium, sodium and calcium. It is used in glassmaking as a source of alumina and alkalis, in ceramic bodies and glazes, in cleaning compounds as a moderate abrasive and as a flux coating on welding rods. High calcium feldspars, such as labradorite, and feldspar-rich rocks, such as anorthosite, find limited use as building stones and for other decorative purposes. Potash feldspar is an essential ingredient in the manufacture of high-voltage porcelain insulators. Dental spar, which is used in the manufacture of artificial teeth, is a pure white potash.

OUTLOOK

Increased recycling of glass in North America is expected to continue to impinge upon the consumption of nepheline syenite and feldspar.

On the positive side, research continues on the development of glass containers that are strong, light weight (thinner glass wall) and safer (glass wall covered with plastic foam) which would be competitive with other container materials. The long term goal is to produce glass containers that would weigh about half their present weight. Although the new product would require less raw materials, the additional demand may more than offset the reduction in unit consumption of raw materials.

Innovative marketing strategies in fields such as packaging is an area where the glass container industry could focus its efforts in order to become more competitive.

PRICES OF FELDSPAR AND NEPHELINE SYENITE IN U.S. CURRENCY

	1985	1986	1987
		($/tonne)	
FELDSPAR			
Ceramic grade, bulk			
f.o.b. Spruce Pine, N.C., 170-250 mesh	48.50	48.50	48.50
f.o.b. Monticello, Ga, 200 mesh, high potash	81.00	81.00	81.00
f.o.b. Middleton, Conn., -200 mesh	58.68	58.68	58.68
Glass grade, bulk			
f.o.b. Spruce Pine, N.C., 97.8% + 200 mesh	32.34	33.89	33.89
f.o.b. Middleton, Conn., 96% + 200 mesh	42.98	42.98	42.98
f.o.b. Monticello, Ga, 92% + 200 mesh, high potash	59.50	59.50	59.50
NEPHELINE SYENITE			
Canadian, CL-car lots TL-truck lots			
Glass grade, 30 mesh, bulk CL/TL, low iron	28.65-31.40	30.85- 33.61	30.35- 33.61
Glass grade, 30 mesh, bulk CL/TL, high iron	22.04-25.62	23.69- 27.24	23.69- 27.24
Ceramic grade, 200 mesh, bagged 10-ton lots	60.60-62.81	70.53- 72.73	70.53- 72.73
Filler/extender grade	73.83-93.67	93.67-109.10	93.67-109.10

Source: Industrial Minerals, December 1985, 1986, 1987.
f.o.b. Free on board.

TABLE 1. CANADA, NEPHELINE SYENITE PRODUCTION, EXPORTS AND CONSUMPTION, 1984-87

	1984		1985		1986		1987P	
	(tonnes)	($)	(tonnes)	($)	(tonnes)	($)	(tonnes)	($)
Production (shipments)	520 640	17 866 091	467 186	17 897 642	467 491	18 921 820	499 147	21 404 000
							(Jan.-Sept.)	
Exports								
United States	334 349	13 689 299	314 092	14 030 751	297 990	14 759 806	235 546	11 560 304
Netherlands	21 830	959 616	17 230	744 763	19 037	1 135 493	10 491	772 286
Italy	10 482	823 460	6 041	467 534	5 672	511 869	1 944	215 664
United Kingdom	5 426	322 467	6 132	319 914	4 856	268 783	177	19 008
Australia	9 933	357 703	1 129	90 328	5 315	360 210	5 980	388 693
Spain	897	63 238	2 294	116 727	1 190	125 162	1 979	204 118
Other countries	4 149	413 699	4 108	530 453	4 197	583 098	2 952	357 531
Total	387 066	16 629 480	351 026	16 300 470	338 257	17 744 421	259 069	13 517 604
Consumption[1]								
Primary glass and containers	55 218	..	43 820	..	58 265	..		
Ceramic products	12 916	..	12 900	..	13 750	..		
Paints	5 843	..	5 924	..	6 095	..		
Others[2]	17 578	..	18 886	..	16 294	..		
Total	91 555	..	81 530	..	94 404	..		

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Available data, as reported by consumers. [2] Includes glass fibre wool and glass fibre, frits and enamel, plastics, structural clay products, paper and paper products, and other minor uses.

P Preliminary; .. Not available.

TABLE 2. TYPICAL RAW BATCH FORMULATION FOR GLASS CONTAINERS AND CERAMICS

Raw Materials	% by Weight
Glass Containers:	
Silica sand	62-63
Nepheline syenite	5-6
Soda ash	21-22
Burnt lime	8-9
Baryte	0-1
Gypsum	0-1
Decolorizers	As required
Cullet	As required
Low temperature ceramic vitreous body:	
Nepheline syenite	54
Kaolin	24
Ball clay	16
Flint	6

Source: Ceramic Bulletin, Vol 65, No 5, 1986.

TABLE 4. CANADA, FELDSPAR CONSUMPTION[1], 1983-86

	1983	1984	1985	1986P
	(tonnes)			
Consumption				
Ceramic products	2 065	1 924	1 924	2 067
Other products[2]	148	182	90	181
Total	2 213	2 106	2 014	2 248

[1] Available data, as reported by consumers.
[2] Includes frits and enamel, abrasives and other minor uses.
P Preliminary.

TABLE 3. CANADA, NEPHELINE SYENITE PRODUCTION AND EXPORTS, 1970, 1975 AND 1979-86

	Production[1]	Exports
	(tonnes)	
1970	454 110	351 940
1975	468 427	356 629
1979	605 699	471 056
1980	600 000	448 468
1981	588 000	476 281
1982	550 480	414 788
1983	523 249	398 299
1984	520 640	387 069
1985	467 186	351 026
1986	467 491	338 257

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Producers' shipments.

TABLE 5. CANADA, CONSUMPTION AND VALUE OF IMPORTS OF CRUDE OR GROUND FELDSPAR, 1975 AND 1979-86

	Imports ($)	Consumption[1] (tonnes)
1975	..	5 630
1979	501 000	4 588
1980	385 000	4 051
1981	642 000	4 606
1982	251 000	2 790
1983	309 000	2 213
1984	310 000	2 106
1985	308 000	2 014
1986	357 000	2 248

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Available data, as reported by consumers
.. Not available.

TABLE 6. WORLD MINE PRODUCTION OF FELDSPAR, 1985 AND 1986

	1985P	1986^e
	(000 tonnes)	
United States	635	667
Brazil	120	120
France	209	200
Germany, Federal Republic of	322	320
Italy	1 116	1 237
Mexico	100	100
Spain	136	135
Korea, Republic of	145	140
Thailand	104	100
U.S.S.R.	335	336
Other Countries	856	845
Total	4 078	4 200

Source: United States Bureau of Mines Mineral Commodity Summaries, 1986.
^{e} Estimated; P Preliminary.

Nickel

R.G. TELEWIAK

Nickel consumption, led by strong demand from the stainless steel sector, is estimated to have increased in the western world by 7% in 1987, to a record 615 000 tonnes (t). Consumption was strong in all three major market areas - western Europe, United States and Japan.

Supplies were tight as western world production plus net exports from the Soviet Union and Cuba were about 20 000 t less than consumption. Due to the tight market and relatively low inventories, prices rose precipitously in the second half of the year.

Prices on the London Metal Exchange averaged US$1.67/lb. for the first quarter of 1987 and $2.92 for the fourth quarter. A record high of US$4.24 was reached on December 30. The steep price rise in the last half of December was partially due to the cessation of exports by Falconbridge Dominicana C. por A. when the Dominican Republic imposed a tax on mineral exports.

CANADIAN DEVELOPMENTS

Due to the strong international market conditions, Inco Limited and Falconbridge Limited, the two domestic integrated producers of nickel, increased nickel production in Canada, with most of the increase occurring at Thompson, Manitoba. Preliminary figures put domestic production at 187 800 t compared with 163 600 t in 1986.

In the Sudbury district, Inco resumed production in May from its Crean Hill mine. The mine had been on standby since 1978. In the fall of 1986, Inco had started to modernize the mine by installing new equipment and converting the mine to bulk mining. The mine is now all-electric which provides for a cleaner and quieter working environment. Initial output was about 300 t/d and is expected to increase to 3 000 t/d by January 1988. Output is expected to be about 24 t per manshift compared to about 8 t when the mine last operated.

Inco also started production from the Creighton deep ore zone. This high grade zone is one of Inco's lowest cost sources of ore. Due to a mechanical problem with the hoist motor on the Number Nine shaft, production from the Creighton mine was partially reduced for the latter part of the year. The company increased production at other mines at Sudbury and also at Thompson to try to make up for the lost production.

Late in the year, Inco announced that it would be proceeding with development of the Lower Coleman orebody. The $51 million project involves deepening the Coleman shaft from 2280 feet to 3450 feet and driving two 3000 foot access ramps. The mine will be converted to all-electric operation and will be in full production by 1990.

At Thompson, Manitoba, Inco announced that it would be spending $27 million to develop an orebody at depths between 2400 and 3200 feet at the north end of the Thompson mine. Production is scheduled to start from the orebody late in 1988 and it is expected that the orebody will provide 5 Mt of nickel ore over the next 15 years.

Falconbridge closed its Sudbury operations in July and August, the first summer shutdown that the company had taken since 1982. The decision to take the summer shutdown had been made in late 1986 when it appeared that market conditions would be weak in 1987.

Falconbridge continued its three-year, $200 million program of preproduction, development and capital expenditures which was started at Sudbury in 1985. Major parts of the program include deepening the Strathcona No. 1 shaft and development of the Craig and Onaping deposits. Falconbridge had fallen behind in mine development a few years ago, due to other priorities.

At its Lindsley property, 20 km west of Sudbury, the company announced some promising drilling results. One drill hole,

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over a core length of 255.5 feet, intersected mineralization averaging 2.35% nickel and 4.41% copper plus associated metals. Follow-up drilling has located no other zones as rich in mineralization but drilling at year-end was continuing on the property.

Inco and Falconbridge continued their efforts to develop solutions to conform to the 1994 sulphur dioxide emission limits set in December 1985 by the Ontario government. Inco is required to reduce emissions to 265 000 t/y of sulphur dioxide, compared with 685 000 t/y in 1986. For Falconbridge, the limit in 1994 will be 100 000 t/y compared with 154 000 t/y in 1986. Enhanced pyrrhotite rejection has potential for a partial solution to both companies' abatement requirements. Both are conducting further research and development before deciding which options will be technically viable and most cost-effective. The companies are required to submit a final abatement plan to the Ontario government by December 1988.

Sherritt Gordon Mines Limited produced about 21 300 t of nickel in briquettes and powder at its Fort Saskatchewan, Alberta refinery. Inco continued to be the major source of feed, with concentrates from Thompson and matte from Sudbury. Sherritt Gordon reached an agreement with Hudson Bay Mining and Smelting Co., Limited for refining the latter's 60% share of the concentrate to be produced at Namew.

Hudson Bay Mining and Smelting Co., Limited and Outokumpu Oy commenced development of the Namew Lake deposit near Flin Flon, Manitoba. Reserves are estimated to be 2.6 Mt grading 2.4% nickel and 0.9% copper with minor values in platinum and palladium. Production is expected to be about 8 000 t/y of contained nickel in concentrate and is expected to commence in the fourth quarter of 1988. Mine life is expected to be about 6 years.

Inco announced late in the year that it would again be taking summer shutdowns in 1988. The Sudbury and Port Colborne operations are scheduled to close from June 27 to August 1 and Thompson is scheduled to close from July 14 to August 7. Surface facilities will continue to be operated at Thompson.

Canadian nickel consumption is expected to have increased marginally in 1987 from 1986. Consumption was higher at both the Atlas Steels division of Rio Algom Limited and the coinage sector. Stainless steel production was higher and due to the introduction by the Royal Canadian Mint of the bronze-coated nickel dollar coin, coinage production increased.

WORLD DEVELOPMENTS

Nickel consumption was strong in all major market areas. Stainless steel production, which accounts for about 55% of nickel consumption, was particularly strong. Much of the increase in demand for stainless steel came from the capital goods sector as companies in the manufacturing sector refitted and added new capacity.

Supplies of scrap were tight and this increased the demand for primary nickel. Normally about one half of the nickel used in the production of stainless steel is scrap, both internally generated and from outside sources, but in 1987 this ratio decreased somewhat.

Nickel producers increased their operating rate in the second half of the year after they realized that nickel consumption was increasing substantially. At the end of the year most producers were operating at or close to their effective capacities.

Net exports from COMECON countries to the western world decreased to an estimated 50 000 t from 55 000 t the previous year. Exports from the Soviet Union decreased to about 43 000 t from 50 000 t in 1986. Cuban exports were about 9 000 t, which were about the same as in 1986. China exported about 5 000 t compared to 3 000 t the previous year. Other eastern European countries exported about 1 000 t. COMECON countries imported about 8 000 t from the western world.

In Australia, Metals Exploration Ltd. closed its Nepean mine in Western Australia after ore reserves were depleted. Freeport Queensland Nickel Inc. sold its 50% interest in Queensland Nickel Pty. Ltd., which operates the Greenvale nickel project in Queensland, Australia, to Dallhold Investments Pty. Ltd., controlled by Mr. Alan Bond. The other joint venture partner in the project is Metals Exploration Queensland Pty. Ltd.

A drilling program was undertaken on the deep zone of the Agnew mine in Western Australia. Mining of the upper oxidized layer of the deposit had resulted in difficulties due to unstable rock conditions, and efforts were being concentrated on defining the mineralization which occurs at depth. A small deposit which can be mined by open-pit methods also exists nearby and would be mined whenever the operation reopens. Agnew is considered to be one of the highest quality deposits not currently being mined but sustained prices close to US$3.00/lb. are needed to reactivate this operation.

In Japan, Nippon Mining Company Limited closed its Oita ferronickel plant at the end of September. The plant had a capacity of 800 t/m of contained nickel but had been unprofitable due to relatively low nickel prices and the rising value of the yen compared to the U.S. dollar. The plant had also been experiencing some technical difficulties. The Tokyo Nickel Company, Ltd. expanded the capacity of its Matsuzaka plant from 16 000 t/y to 32 000 t/y. The plant processes nickel matte from P.T. International Nickel Indonesia into nickel oxide sinter. Upon completion of the expansion, the old roaster was closed for repairs.

Nihon Nickel Limited, which had been toll refining some nickel oxide for Tokyo Nickel, is expected to be left without a feed supply and is anticipated to close. The company, which is 60% owned by Nippon Yakin Kogyo Co., Ltd., 24% by Nippon Mining and 16% by Pacific Metals Co., Ltd., had been producing about 200 to 300 t/m of nickel oxide. Nihon Nickel had earlier lost its supply contract with Société Métallurgique Le Nickel.

In Indonesia, P.T. International Nickel took a three week summer shutdown and produced about 27 000 t in 1987 compared with 21 800 t in 1986. The company has announced that there will be no summer shutdown in 1988 and production will be 34 000 to 36 000 t.

Société Métallurgique Le Nickel undertook some repair work on one of its three electric furnaces in New Caledonia and production was affected for part of the year. Production in 1988 is planned to be 46 000 t compared with about 36 000 t in 1987.

In China, some production problems were being experienced at the Jinchuan complex in Gansa province, due to flooding which occurred in June. Late in the year, China was reported to be considering a duty or a ban on nickel exports but, according to the China National Nonferrous Metals Import and Export Corporation, a final decision had not been made.

Nonoc Mining & Industrial Corporation in the Philippines did not operate its Surigoa nickel refinery during the year. In 1986, it had operated intermittently but due to weak markets it was closed by year-end. Increasing prices in 1987 caused greater interest in re-examining the viability of the operation. Restarting costs are estimated at more than $100 million over several months.

In Brazil, Companhia Niquel Tocantins announced that it is planning to increase its nickel capacity to 10 000 t/y by 1990 and to 15 000 t/y within the following two to three years, with a possible future expansion to 20 000 t/y. British Petroleum Mineracao SA, announced that it plans to spend $250 million to develop a mine, concentrator, smelter and 8 000 t/y electrolytic nickel refinery in the state of Minas Gerias. Ore reserves are 5.3 Mt grading 2.6% nickel.

In the Dominican Republic, Falconbridge raised its equity interest in Falconbridge Dominicana to 85.2% with the purchase of Armco Inc.'s 17.5% equity interest. In mid-December, Falconbridge suspended ferronickel shipments, but continued to produce, after the government announced Decree 578-87 which taxed exports of sugar and minerals. The tax is tied to the exchange rate of the peso to the U.S. dollar.

In Cuba, production at the Punta Gorda plant was reported to be about 1500 t. The technical problems which have plagued the operation since production started in late 1985 were reported to be near resolution and production at the 30 000 t/y plant is expected to be much higher in 1988.

Production at Hellenic Mining and Metallurgical Company of Larymna S.A. (LARCO) in Greece was increased late in the year to take advantage of the strong market conditions. One more electric furnace was bought on-stream to bring the total operating to three. Two of the four rotary kilns were also operating.

Outokumpu Oy closed its Harjavalta nickel refinery in Finland for six weeks in July and August but continued to take normal deliveries of feed during the shutdown and the copper smelter continued to operate. Production was subsequently curtailed for a further two weeks by a strike at the Harjavalta complex.

Late in 1986, the United States and the Soviet Union reached a tentative agreement that would permit a resumption of Soviet nickel imports. In 1983, the United States had banned the importation, directly or indirectly, of Soviet nickel after it had been determined that the Soviet nickel product contained Cuban nickel. The Soviet Union imports about half of Cuba's nickel oxide production for refining at Monchegorsk on the Kola Peninsula. However, no final agreement could be reached in 1987. Difficulties were reported in obtaining final wording acceptable to both parties.

INTERNATIONAL NICKEL STUDY GROUP

At the United Nations Conference on Nickel, October 28 to November 7, 1985 and April 28 to May 2, 1986, negotiations took place involving over thirty nickel producing and consuming countries, on the Terms of Reference and Rules of Procedure for the International Nickel Study Group (INSG). The United Nations Conference on Trade and Development (UNCTAD) provided the facilities and services for the meetings, which were chaired by Canada.

The functions of the INSG, as stated in the Terms of Reference which were adopted by the Conference, are:

(a) to establish the capacity for and to undertake the continued monitoring of the world nickel economy and its trends, particularly by establishing, maintaining and continuously updating a statistical system on world production, stocks, trade and consumption of all forms of nickel;

(b) to conduct between Members consultations and exchanges of information on developments related to the production, stocks, trade and consumption of all forms of nickel;

(c) to undertake studies as appropriate on a broad range of important issues concerning nickel, in accordance with the decisions of the Group; and

(d) to consider special problems or difficulties which exist or may be expected to arise in the international nickel company.

Inauguration of the INSG must await membership commitments from at least 15 countries accounting for 50% of world trade in nickel.

Seven countries with 30% of trade made membership commitments before the end of 1986 (Canada, Netherlands, France, Finland, Sweden, West Germany and Greece), but little further progress was made for some time. Accordingly, Canada and the Netherlands arranged an informal meeting of interested countries on the margins of the Ad Hoc Preparatory Meeting on Copper in Geneva. At the November 20, 1987 meeting, Australia, the U.S.S.R. and Norway confirmed their intention to join as quickly as possible. Cuba stated that it would join effective with the inaugural meeting. These bring membership commitments to eleven countries accounting for 51% of trade.

It is anticipated that additional countries will be joining within the next few months. The inaugural meeting of the INSG can then be scheduled.

PRICES

Nickel prices strengthened as the year progressed. Average quarterly nickel prices on the London Metal Exchange (LME) were US$1.67, $1.93, $2.33 and $2.92, respectively. The average price for the year was $2.21 compared with $1.76 in 1986.

Market conditions became very tight in the latter part of the year. Consumption was strong throughout the year and while consumption is often lower in the third quarter due to seasonal factors, consumption remained strong throughout 1987. Production was lower than consumption for the year as a whole, and inventories dropped by an estimated 20 000 t.

Soviet exports were lower than in 1986 and this added to the tight market conditions. In the fourth quarter, there were reported to be some supply problems at Norilsk and this could have been a factor in the relatively low level of exports late in the year.

Scrap supplies were tight and prices firmed throughout the year. Stainless steel production was at record levels and the demand for scrap from this sector was particularly strong.

Inco sold utility nickel to stainless steel producers in Europe under a new producer pricing arrangement. About 18 000 t were sold on this basis. The stainless steel producers had been requesting such an arrangement and in the third and fourth quarter of 1987, Inco set the price at US$1.98/lb. For the first quarter of 1988, Inco has agreed to a price of US$2.65. Under the plan, Inco's customers can choose the set price or the LME cash nickel price plus 3 cents.

USES

Resistance to corrosion, high strength over a wide temperature range, pleasing appearance and suitability as an alloying agent are characteristics of nickel which make it useful in a wide range of applications. The major use is in stainless steels, which account for about 55% of consumption, followed by nickel-base alloys, electroplating, alloy steels, foundry products and copper-based alloys. Nickel is extensively used as an alloying agent and is a component in some 3 000 different alloys which are used in more than 250 000 end-use applications.

Close to two-thirds of nickel consumption is in capital goods with the remainder in consumer products. Nickel is used in chemical and food processing, nuclear power plants, aerospace equipment, motor vehicles, oil and gas pipelines, electrical equipment, machinery, batteries, catalysts, and in many other applications.

Relatively new end-use markets that will contribute to nickel's consumption growth in the future are pollution abatement equipment, cryogenic containers, barnacle-resisting copper-nickel alloy plating for boat hulls, and nickel-cadmium batteries for standby power applications.

Some new alloys developed recently could have an attractive future. One of these, a zinc-nickel alloy, is being used by Mazda in Japan for use in a galvanizing process for automobile applications and is being examined by other automotive manufacturers. The product is more corrosion resistant than regular galvanized steel. The enhanced appearance and low weight make this type of product potentially attractive for certain other uses, such as galvanized steel lamp posts.

Another nickel-based alloy, altraloy, has been developed which may displace gold in some electronic applications. Nickel is combined with iridium to make a low-cost connector or surface contact material.

OUTLOOK

The global overcapacity which characterized the industry in the early 1980s has been substantially reduced due to plant closures and increasing levels of nickel consumption. Nevertheless, some overcapacity is expected to continue through the remainder of this decade.

Over the medium to longer term, there are some encouraging developments which should affect the market. Nickel producers have reduced their production costs in recent years, primarily due to reduced employment and the introduction of improved techniques and equipment, and it is expected that many of these cost-cutting measures will be permanent. As a result, nickel prices will not need to be as high as previously thought for producers to be profitable. Prices are likely to be lower than many analysts were forecasting a few years ago and this will encourage increased consumption and reduce the threat of substitution by other metals, plastics, ceramics and other materials.

The Nickel Development Institute, which was established in 1984, is also likely to have a positive impact on demand over the longer term. The Institute, headquartered in Toronto and supported by most major western world producers, is encouraging the use of nickel through market promotion programs and research into new uses for nickel. The Institute had initiated numerous market development, market exploration and end-use research projects in various parts of the world. Small liaison offices to serve different market areas have been set up in the United Kingdom, Japan, India and Brazil.

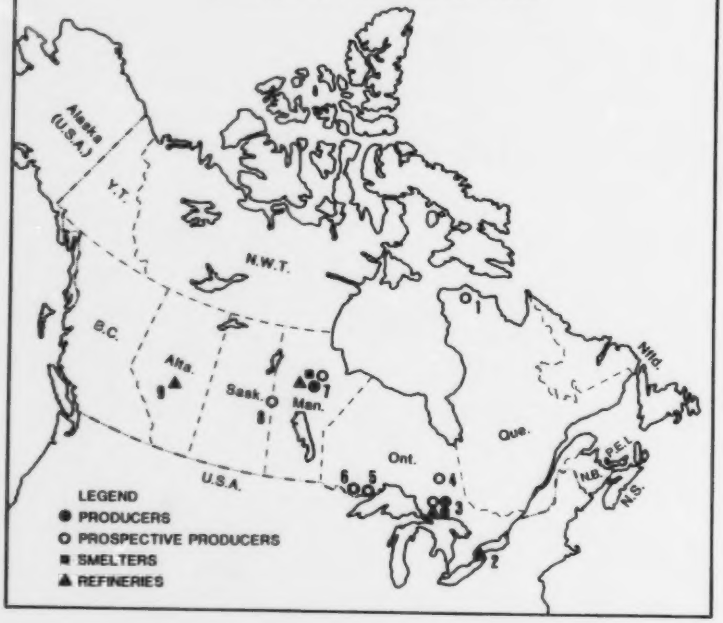
Given the expected, relatively modest nickel prices and the high costs of establishing new capacity, return on investment is not likely to be sufficient to encourage installation of much new capacity for the next few years. However, a closer balance between capacity and consumption in the 1990s will encourage new capacity to be added.

Consumption is expected to grow at an annual rate of about 1.7% to the year 2000. While some more mature markets, like the United States and Japan, are expected to experience somewhat lower growth rates, this will be offset by higher rates in relatively small but emerging markets such as China, Brazil and South Korea.

Nickel production in Canada is expected to increase slowly to the year 2000 (Table 6) but will unlikely reach the 1970 peak production of 277 000 t. Canada is expected to remain a highly cost-competitive producer, particularly given the cost reduction programs which are under way. An increasing amount of ore will be mined by low-cost bulk mining methods and this will be a significant factor in lowering costs, given that mining accounts for about 50% of current operating costs. The Thompson open pit will also supply low cost ore. A constraint on production, particularly at Inco, Sudbury, will be the limit on permissible sulphur dioxide emissions from the smelter.

In the short-term, producers in the western world will continue, as occurred in the fourth quarter of 1987, to operate at or near their effective capacities. Supplies will remain relatively tight at least for the first few months of 1988, particularly if Soviet exports remain at or near 1987 levels. Producers will generally be taking fewer summer shutdowns and this will result in additional supplies compared to 1987. Prices are expected to retreat somewhat from the high levels prevailing at the end of 1987 but a factor which could potentially disrupt the market is the expiry of current labour contracts at Inco and Falconbridge at Sudbury in May and August 1988, respectively. As well, a continuation of Falconbridge's curtailment of exports from the Dominican Republic for several weeks, or more, would put upward pressure on prices.

NICKEL IN CANADA, 1987


Alaska (U.S.A.)
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LEGEND
● PRODUCERS
○ PROSPECTIVE PRODUCERS
■ SMELTERS
▲ REFINERIES

Producers, prospective producers, smelters and refineries
(numbers refer to locations on map above)

Producers

3. Falconbridge Limited
   (Craig, East, Falconbridge open pit, Fraser, Lockerby, Onaping, Strathcona)
   INCO Limited
   (Copper Cliff North, Copper Cliff South, Crean Hill, Creighton, Frood, Garson, Levack, Little Stobie, McCreedy West and Stobie)
7. INCO Limited (Thompson and Thompson open pit)

Prospective Producers

1. New Quebec Raglan Mines Limited
3. Falconbridge Limited
   (Lindsley, Onex, Thayer)
   INCO Limited (Clarabelle, Coleman, Garson, Crean Hill, Murray, Totten)
4. Teck Corporation (Moncalm Township)
5. Great Lakes Nickel Limited (Pardee Township)
6. INCO Limited (Shebandowan mine)
7. INCO Limited
   (Soab North, Soab South, Birchtree, Pipe No. 1)
8. Hudson Bay Mining and Smelting Co., Limited (Namew Lake)

Smelters

3. Falconbridge Limited (Falconbridge)
   INCO Limited (Sudbury)
7. INCO Limited (Thompson)

Refineries

2. INCO Limited (Port Colborne)
3. INCO Limited (Sudbury)
7. INCO Limited (Thompson)
9. Sherritt Gordon Mines Limited (Fort Saskatchewan)

TABLE 1. CANADA, NICKEL PRODUCTION, TRADE AND CONSUMPTION, 1985-87

	1985r		1986		1987P	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Production[1]						
All forms						
Ontario	131 035	930 760	121 851	731 440	131 528	902 417
Manitoba	38 936	286 628	41 789	247 660	56 277	386 114
Total	169 971	1 217 388	163 640	979 100	187 805	1 288 531
Exports					(Jan. - Sept.)	
Nickel in ores, concentrates and matte						
Norway	33 337	196 935	29 332	162 920	24 095	116 606
United Kingdom	29 895	212 199	28 447	202 089	21 025	149 058
United States	61	427	1	4	-	-
Other	12	96	-	-	-	-
Total	63 305	409 657	57 780	365 013	45 120	265 664
Nickel in oxides						
United States	9 284	54 749	..	29 384	..	19 497
EEC	1 390	12 244	..	8 992	..	9 990
Other countries	7 318	58 417	..	45 108	..	50 928
Total	17 992	125 410	13 923	83 484	11 973	80 415
Nickel and nickel alloy scrap						
United States	2 577	12 428	3 998	17 540	3 408	14 376
Netherlands	1 286	7 916	1 091	4 283	784	3 573
South Korea	265	1 800	156	874	174	909
Other countries	698	3 618	813	1 037	1 589	3 383
Total	4 826	25 762	6 058	23 734	5 955	22 241
Nickel anodes, cathodes, ingots, rods						
United States	..	279 473	..	289 208	..	212 274
EEC	..	128 918	..	120 771	..	93 538
Other countries	..	87 453	..	67 910	..	78 821
Total	81 690	495 844	86 004	477 889	86 379	384 633
Nickel and nickel alloy fabricated material, n.e.s.						
United States	8 663	69 186	7 823	61 224	8 520	61 302
South Africa	866	7 567	1	37	2	25
Belgium-Luxembourg	573	3 164	505	2 867	316	1 768
United Kingdom	417	2 509	401	2 186	340	1 787
Japan	1 124	9 697	1 007	6 927	858	7 836
Other countries	595	5 251	1 035	7 398	1 234	8 672
Total	12 342	98 001	10 772	80 639	11 270	81 390

Imports						
Nickel in ores, concentrates and scrap						
Australia	6 250	32 332	10 219	44 115	2 902	9 743
United States	15 486	24 181	14 748	18 327	6 903	10 131
United Kingdom	6 567	7 733	9 642	13 069	5 266	6 326
Belgium-Luxembourg	2 112	1 710	831	894	-	-
Norway	97	461	2 348	2 136	176	1 042
Other countries	1 082	2 428	542	1 149	412	468
Total	31 594	68 845	38 330	79 690	15 659	27 710
Nickel anodes, cathodes, ingots, rods						
Norway	1 788	13 143	1 737	11 651	1 580	8 913
United States	917	6 974	1 108	7 273	608	3 555
United Kingdom	17	173	40	258	20	122
Netherlands	-	-	20	116	-	-
Other countries	42	313	58	498	12	92
Total	2 764	20 603	2 963	19 796	2 220	12 682
Nickel alloy ingots, blocks, rods and wire bars						
United States	391	4 665	424	5 648	438	4 979
West Germany	184	1 363	66	599	75	541
Other	1	11	-	-	54	208
Total	576	6 039	490	6 247	567	5 728
Nickel and alloy plates, sheet, strip						
United States	603	9 812	578	8 411	529	6 377
West Germany	658	4 159	703	4 802	630	4 272
Sweden	17	93	30	301	60	379
Other countries	29	258	24	1 176	6	156
Total	1 307	14 321	1 335	13 754	1 225	11 184
Nickel and nickel alloy pipe and tubing						
Sweden	233	2 331	70	1 312	8	39
United States	128	2 187	126	2 474	154	2 543
West Germany	67	783	45	557	24	345
Other countries	95	1 459	240	3 041	23	317
Total	523	6 760	481	7 384	209	3 244
Nickel and alloy fabricated material, n.e.s.						
United States	627	19 203	534	19 313	515	15 167
United Kingdom	17	239	65	460	31	277
West Germany	155	1 998	106	1 159	74	839
Other countries	29	376	7	99	16	130
Total	828	21 816	712	21 031	636	16 413
Consumption[2]	5 932	..	6 605	..		

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Refined nickel and nickel in oxides and salts produced, plus recoverable nickel in matte and concentrates exported.

[2] Consumption of metallic nickel, all forms (refined metal and in ferronickel, oxides and salts) as reported by consumers on the EMR survey, "Consumption of Nickel".

P Preliminary; r Revised; - Nil; .. Not available; n.e.s. Not elsewhere specified.

TABLE 2. CANADA, NICKEL PRODUCTION, TRADE AND CONSUMPTION, 1970, 1975 AND 1980-87

		Exports					
	Production[1]	In Matte etc.	In Oxide Sinter	Refined Metal	Total	Imports[2]	Consumption[3]
				(tonnes)			
1970	277 490	88 805	39 821	138 983	267 609	10 728	10 699
1975	242 180	84 391	38 527	91 164	214 082	12 847	11 308
1980	184 802	42 647	16 989	88 125	147 761	4 344	9 676
1981	160 247	53 841	14 390	79 935	148 166	2 335	8 603
1982	88 581	27 037	13 127	62 314	102 478	2 588	6 723
1983	125 022	40 087	11 167	66 949	118 203	2 357	5 010
1984	173 725	59 409	20 079	153 935	233 423	3 480	7 290
1985r	169 971	63 305	17 971	81 690	159 542	2 764	5 932
1986r	163 640	57 780	13 923	86 004	157 707	2 963	6 605
1987P	187 805	..	..	..	..	..	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Refined metal and nickel in oxide and salts produced, plus recoverable nickel in matte and concentrates exported. [2] Refined nickel, comprising anodes, cathodes, ingots, rods and shot. [3] Consumption of metallic nickel, all forms (refined metal, and in ferronickel oxides and salts) as reported by consumers on the EMR survey "Consumption of Nickel".
P Preliminary; r Revised; .. Not available.

TABLE 3. CANADIAN PROCESSING CAPACITY, 1987

	Inco			Falconbridge	Sherritt Gordon
	Port Colborne	Sudbury	Thompson	Sudbury	Fort Saskatchewan
			(tpy of contained nickel)		
Smelter	n.a.	127 000[1]	81 600	45 000	n.a.
Refinery	30 000	56 700	55 000	n.a.	24 000

[1] Reduced from 154 200 t due to a government regulation on SO_2 emissions imposed in 1980. Due to current nickel market conditions, effective capacity is closer to 110 000 t.
n.a. Not applicable.

TABLE 4. WORLD MINE PRODUCTION OF NICKEL, 1985 AND 1986

	1985	1986
	(tonnes)	
U.S.S.R.	172 000	170 000
Canada[1]	170 000	163 600
Australia	85 800	78 900
New Caledonia	61 200	71 300
Indonesia	48 200	67 300
Cuba	33 600	35 100
South Africa	29 000	29 000
Botswana	19 600	19 000
People's Republic of China	19 000	22 000
Dominican Republic	25 400	24 100
Other	177 000	94 200
Total	787 400	774 500

Sources: World Bureau of Metal Statistics; Energy, Mines and Resources Canada.

[1] Refined nickel and nickel in oxide and salts produced, plus recoverable nickel in matte and concentrates produced.

TABLE 5. WORLD CONSUMPTION OF NICKEL, 1985 AND 1986

	1985	1986
	(tonnes)	
U.S.S.R.	150 000	150 000
United States	143 000	125 000
Japan	136 000	127 000
Germany, F.R.	75 000	77 300
France	31 900	31 900
Italy	29 000	29 500
United Kingdom	24 800	27 400
People's Republic of China	18 500	29 500
Sweden	17 000	17 100
India	14 200	16 000
Other	143 500	165 900
Total	782 700	786 600

Sources: World Bureau of Metal Statistics; Energy, Mines and Resources Canada.

TABLE 6. CANADIAN NICKEL PRODUCTION

					Forecast				
Year	1971-80	1981-85	1986	1987	1988	1989	1990	1995	2000
				(000 tonnes)					
Production	217.5	142.8	163.6	187.8	191	199	205	205	207

Peat

M. PRUD'HOMME

Peat is an intermediate compound resulting from the biochemical decomposition of plant matter. In its raw material form, it is ligneous, fibrous and elastic. It has a pH of 2.8 to 4.0 and an ash content of 0.5 to 2.5%. Peat is composed of organic residues accumulated from the anaerobic decomposition of plant matters. Peat is found in peat bogs, swamps and marshes. Its main properties are its high water-retaining capacity, low density, high resistance to decomposition, low heat conductivity and high porosity. It can hold up to twenty times its weight in liquids and gas. Peat is divided into two principal types according to its botanical composition and degree of decomposition. Horticultural peat is relatively undecomposed, with a von Post value of H1 to H5. It has a high fibre content, is light yellowish brown in colour and contains few colloids. Fuel peat is highly decomposed, with a von Post value of H6 to H10. It is blackish in colour and contains colloid residues.

The total area of peatlands in Canada is estimated at 111 328 000 hectares (ha), covering close to 12% of the country's land surface. Approximately 60% of all Canadian peatlands are perennially frozen. Indicated peat resources total approximately 3 004 996 Mm^3, equivalent to 338 000 Mt of dry peat. Measured resources are estimated at 1 092 Mt. In Canada, close to 280 000 ha of peatland are currently used for agricultural purposes.

Peat production in Canada is limited to a short harvesting season - from June to September due to weather conditions which hinder drainage and drying of the peat.

Canada mainly produces sphagnum peat, which is used in horticulture and agriculture. It is harvested primarily in eastern and southeastern Quebec, and in northeastern and eastern New Brunswick. A small amount of hypnum moss is also produced in Alberta and Ontario. Peat moss is the terminology for commercial use of peat in horticulture.

USES

Sphagnum peat is extracted from peatlands and dried. After the fibres are removed, it is pressed into bales. It is marketed in three forms. In its natural state, peat is sold in bulk form within a 100 km radius of production centres. When packaged in bags or bales, peat is compressed using a ratio of 2:1. The most common bale sizes are 170 dm^3 (6 ft^3), 113 dm^3 (4 ft^3), and 56 dm^3 (2 ft^3). Peat is mixed with fertilizers and other products, such as vermiculite and perlite, to form a substrate, and with limestone, soil and fertilizers to form potting soil.

Because of the range of its physical and chemical properties, peat has many uses. It is used in its natural state in agriculture and horticulture to loosen up clay soils, to maintain moisture in sandy soils and to add organic matter and fertilizers to depleted soils. Peat is also used as a horse, cattle and poultry litter to absorb liquids and odours. Peat is used in the production of artificial mixtures such as potting soil, seed carriers, peat-perlite and peat-vermiculite mixes, fertilizers and composts. It is used in the production of peat pots for sprouting plants.

Peat has several industrial applications. It can be used in the production of paper towels, chemical products, metallurgical coke and activated carbon (charcoal). Peat is also used to purify industrial and residential effluents. Its cellular structure, absorbing properties and high capacity for ionic exchange constitute adequate qualities for it to be used as a natural filter. Peat can reduce the acidity of drainage from old mines and remove iron oxydes from waste and drainage water. Peat acts as an aid for therapy in balneology, gynaecology and

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rheumatology. Peat moss has been used as an oil spillage absorbent and in medical tampons.

Fuel peat is recognized as an alternate source of energy. This form of biomass is widely used as fuel in several European countries, such as Ireland and Finland, and in the U.S.S.R. The calorific value of dry Canadian peat is approximately 4 700 to 5 100 kcal/kg, compared with oil at 9 900 to 10 000 kcal/kg and coal at 4 800 to 5 800 kcal/kg. Peat, as a fuel, is fired in furnaces to produce the steam needed to drive turbines generating electricity. Fuel peat can be processed to produce coke, synthetic natural gas and methanol. Fuel peat has a high degree of humification, a high bulk density, a high calorific value, a low ash content, and a low percentage of pollutants such as sulphur and mercury.

PRODUCTION AND TRADE IN CANADA

In 1987, peat production in Canada rose drastically compared to the 1986 level. Increases were recorded in all producing provinces, but particularly in Quebec with a 200% increase over 1986. The harvesting season started early in April with exceptionally good weather up to the end of June and then; mild and windy weather up to early September. In Quebec inventories have more than doubled while in New Brunswick, they have grown by at least 20%.

There was an acute shortage of supplies until production started in early April, resulting in softer prices compared to prices that prevailed during late 1986 - early 1987.

The value of 1987 shipments increased 2.7% to $82.4 million as the average unit value rose by 5% to $114.36/t, due to increases in New Brunswick, Manitoba and Saskatchewan. Peat shipments totalled 720 354 t, a drop of 2.6% from 1986. Quebec accounted for 41.6% of total peat shipments in terms of tonnage followed by New Brunswick (33.4%), Alberta (10.2%) and Manitoba (8.6%). More than 90% of Canadian peat production is for use in horticulture, nurseries, landscaping, and potato and mushroom growing. Apparent consumption of peat in Canada is estimated at 10% of the total volume of shipments, the remainder being exported.

In 1986, imports of peat moss in Canada were valued at $709 000 and were mainly from the United States (57%) and Norway (15%). Imports were mainly shipped to Ontario (75%) and Quebec (15%). Canadian exports totalled 535 003 t, a 20% increase over 1985. In the first nine months of 1987, Canada exported about 358 000 t, a 33% drop compared to the same period in 1986; this dramatic decline resulted from the seasonal shortages due to a poor weather-related production during the 1986 harvesting period.

The United States accounted for 93% of our exports, followed by Japan (6%). In 1987, new offshore markets were developed which may create further sales opportunities in the near future, particularly in Saudi Arabia, Greece, Australia, northwestern Europe and Egypt. In 1987, the unit value of exported peat reached $220/t, a 10% increase over 1986.

DEVELOPMENTS IN CANADA

In 1987, the Canadian peat industry provided employment to 1425 workers, and accounted for 2.1% of total employment in the Canadian nonfuel mining industry.

In Newfoundland, tests continued at St. Shotts for the production of sod peat fuel and at Bishop's Falls for the harvesting of fuel peat, under the Canada/Newfoundland Conservation and Renewable Energy Demonstration Agreement.

In New Brunswick, new operations started to produce horticultural peat moss bales and mixes; these are Good Earth Canada Ltd. at Point Escuminac, and Berger Mix Inc. at Baie St-Anne. Existing operations began development work on new bogs in northeastern New Brunswick.

In Quebec, Les Tourbières Premier Ltée and the Centre Québécois de Valorisation de la Biomasse (CQVB) signed an agreement to set up a $3.6 million, three-year research and development program for new peat products; the program, called SUbstrat BIologique de TOurbe (SUBITO), will involve research on products made from peat and used for horticultural and environmental purposes, as well as the development, manufacturing and marketing of these products. Projects announced so far involve the development of improved soils, the study of composting techniques; these will be followed by research on biofilter and forest substract.

Johnson & Johnson Inc. and La Compagnie de Papiers St-Raymond Limitée announced a joint project, to be carried out by Produits Desbiens Inc., which is aimed at producing new absorbent materials from purified peat. The absorbent materials will be utilized in the manufacture of various health-care products. The project calls for a $20 million investment for the renovation of the old St-Raymond paper plant at Desbiens, Lac St-Jean, and for the development of new peatland at Sainte Marguerite. The plant is expected to employ 40 people once operations begin in 1989.

In Ontario, INCO Limited, Esso Resources Canada Limited and Lacana Mining Exploration have joined Peat Resources Limited in a project to develop fuel peat from peatlands located in northern Ontario. A $400 000 engineering feasibility and market study will be carried out to examine the economic viability of developing and operating a 250 000 t/y peat processing plant to provide fuel for power generation.

WORLD PRODUCTION AND FOREIGN TRADE

In 1986, world peat production increased 2% to 246.6 Mt, of which 78% was for agricultural and horticultural uses. In 1987, world peat production has been estimated at 246.7 Mt. The U.S.S.R. is the largest producer of agricultural peat, accounting for 97.5% of total world production. Canada ranks fourth, with a 0.3% share.

In the United States, peat production rose 1.5% to 816 000 t in 1987, valued at US$21 million. Commercial sales dropped slightly by 7.8% to 846 000 t, of which 99% came from Canada through New York, North Dakota, Montana, Michigan and Maine. Ninety two operations were active in 21 States, mainly Florida, Michigan, Illinois, Indiana and Colorado, which together accounted for 80% of production. In 1987, apparent consumption was 1 360 000 t. Sphagnum peat moss was mainly used for soil improvement, potting soils and nurseries, and accounted for only 2% of total production which is dominated by reed-sedge and humus peat.

Japan is the second largest importer of Canadian peat, accounting for 6% of total Canadian peat exports in 1986. In 1986, Japan imported about 31 600 t of peat moss, 90% of which was of Canadian origin. Peat moss is sold in three grades: fine, medium and coarse. The demand for peat moss continued to increase as new uses are being developed such as hydroseedings of highways, and uses in bonsaï farms, greenhouses and nurseries. The retail market is largely supplied with small packages ($57 dm^3$) while professionnal buyers prefer larger packages ($170 dm^3$). Peat moss is imported by large trading companies which have sophisticated networks for distribution to wholesalers and professional users. Sphagnum peat moss is used in rice cultivation, horticulture and landscaping. The demand for peat moss in Japan is expected to increase by about 10% a year over the next three years.

OUTLOOK

A balanced market situation for raw peat resumed following a productive summer season in 1987. Higher levels of inventories will likely result in slight downward pressures on prices from the high pricing structure which prevailed during the 1986-87 winter. In the short term, more value-added products such as growing mixes will be manufactured in Canada and will result in improved profitability for peat producers.

The future of the Canadian peat industry depends on its ability to develop new products and new uses and to recognize market opportunities. Canadian producers will likely continue to focus their promotional efforts in broadening its consumer base in traditional markets and in capturing opportunities in overseas markets.

The North American market for raw peat bales is stable and relatively mature; short term growth is forecast at an annual rate of 3%. However, growing medium peat mixes provide good opportunities since demand for mixes is expanding in North America at a growth rate of nearly 10% per year. The Japanese market will continue to expand significantly as demand over the last three years increased drastically at an average growth rate of more than 30% per year. New uses will be developed and new peat products are expected to be sold in Asia.

Overseas markets offer promising export opportunities for Canadian peat producers. New markets could be developed in countries that have selected the agricultural sector as an economic priority, especially in North Africa and the Middle East. Interesting opportunities also exist in western Europe and Oceania as well.

Peat producers will continue research for new peat products for use in horticulture, forestry and industrial applications. Activated carbon, fuel peat, pelletizing agents, fertilizing granules, absorbents and compost additives could become new peat based products which could readily be manufactured in Canada.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
CANADA					
54005-1	Grasses, seaweed, mosses and vegetable fibres other than cotton, not coloured, nor further manufactured than dried, cleaned, cut to size, ground and sifted	free	free	free	free
54010-1	Grasses, seaweed, mosses and vegetable fibres other than cotton, n.o.p.; whether or not dried, cleaned, cut to size, ground and sifted	free	free	17.5	free
71115-1	Pots or compressed pellets wholly or in chief part of peat, for use in growing plants for transplanting purposes, or for protecting plants while growing	6.8	6.8	25	4.5
93100-1	Fertilizer, formulated; Goods for use as fertilizers	free	free	free	free
UNITED STATES			MFN		Non-MFN
192.5000	Peat moss Poultry grade		free		50¢ per long ton
480.8060	Peat moss Fertilizer grade		free		free

Sources: The Customs Tariff 1987, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1987), USITC Publication 1910; U.S. Federal Register.
n.o.p. Not otherwise provided for.

TABLE 1. PRICES[1] IN UNITED STATES, BY TYPE OF PEAT, 1986

Type	Domestic			Imported[2]
	Bulk	Packaged or bales	Average	Total
	(U.S. dollars per short ton)			
Sphagnum moss	20.18	77.78	53.96	125.67
Hypnum moss	24.87	36.24	31.81	..
Reed-Sedge	19.94	27.80	25.16	..
Humus	12.40	43.37	15.00	..
Other	8.98	..	8.98	..

Source: U.S. Bureau of Mines, Peat, C. Davis, 1986.
[1] Prices are f.o.b. mine; [2] Average customs prices.
.. Not applicable; f.o.b. Free on board.

TABLE 2. PEAT RESOURCES OF CANADA

	Peatland Areas		Indicated Volume of Peat (Oven Dry)
	Ha x 10^3	% of Total Canadian Peatlands	tonnes x 10^6
Newfoundland - Labrador	6 429	6	24 945
Prince Edward Island	8	..	30
New Brunswick	120	..	466
Nova Scotia	158	..	613
Quebec	11 713	11	40 057
Ontario	22 555	20	77 138
Manitoba	20 664	19	58 893
Saskatchewan	9 309	8	26 532
Alberta	12 673	11	36 118
British Columbia	1 289	1	4 410
Northwest Territories	25 111	23	65 841
Yukon Territory	1 298	1	2 960
Total	111 328	100	338 003

Source: Peat Resources of Canada, C. Tarnocai, Agriculture Canada, NRCC 24140, 1984.
.. Amount too small to be expressed; Ha hectare.

TABLE 3. CANADA, PEAT SHIPMENTS BY PROVINCE, 1983-87

Province	1983		1984		1985		1986r		1987p	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
	(000 t)	($ 000)	(000 t)	($ 000)	(000 t)	($ 000)	(000 t)	($ 000)	(000 t)	($ 000)
Newfoundland	3	20	1	44	1	120	1.6	149	4	673
Prince Edward Island	0	0	4	1 110	4	685	..	..	..	..
Nova Scotia	10	2 008	5	1 424	9	1 600	..	..	..	..
New Brunswick	151	9 792	151	10 974	175	14 700	228	21 351	240	25 287
Quebec	238	18 216	234	17 170	294	21 870	334	30 059	300	26 250
Ontario	4	546	5	733	6	755	..	..	..	..
Manitoba	54	7 266	71	9 837	87	10 560	..	..	..	..
Saskatchewan	8	1 053	10	1 335	11	1 600	..	..	..	..
Alberta	47	6 585	49	7 555	56	12 455	72	13 930	74	14 395
British Columbia	14	2 324	11	1 634	4	110	..	..	..	..
Total	529	47 810	541	51 816	643	63 770	738	80 152	720	82 384

p Preliminary; r Revised; .. Not available to ensure the confidentiality of data.

TABLE 4. CANADIAN, DOMESTIC EXPORTS OF PEAT, BY COUNTRY, 1983-87

Country	1983		1984		1985^{r}		1986		1987^{P}	
	Tonnage	Value ($ 000)	Tonnage	Value ($ 000)	Tonnage	Value ($ 000)	Tonnage	Value ($ 000)	Tonnage	Value ($ 000)
Australia	231	153	83	54	10	9	61	32	480	109
Barbados	0	0	0	0	20	8	0	0	104	11
Bermuda	186	42	86	40	70	22	40	15	53	9
Chile	5	3	0	0	8	2	0	0	0	-
China	28	6	0	0	0	0	0	0	0	-
Costa Rica	0	0	247	113	85	12	11	3	0	-
Cuba	0	0	0	0	5	3	1	2	0	-
Denmark	0	0	128	137	0	0	0	0	53	26
Dominican Republic	15	5	0	0	0	0	35	15	14	2
Egypt	0	0	0	0	0	0	0	0	27	15
Emirates, U.A.	0	0	30	8	0	0	0	0	0	-
Finland	0	0	0	0	0	0	0	0	7	1
France	0	0	0	0	0	0	0	0	9	5
Germany West	0	0	47	63	11	5	35	14	10	4
Greece	0	0	0	0	0	0	0	0	64	33
Greenland	6	1	0	0	14	8	38	7	18	7
Haiti	12	10	55	26	92	71	143	121	49	33
Honduras	0	0	0	0	30	23	0	0	0	0
Hong Kong	67	21	52	13	20	3	116	18	239	55
India	0	0	0	0	17	1	0	0	0	0
Ireland	0	0	0	0	0	0	0	0	11	3
Israel	95	17	0	0	0	0	0	0	63	16
Italy	0	0	0	0	0	0	0	0	17	5
Japan	17 395	3 676	20 717	4 218	21 029	4 523	31 552	7 240	35 009	7 659
Korea South	30	7	30	7	30	7	50	12	67	16
Kuwait	0	0	0	0	265	82	0	0	40	27
Leeward-Windward Islands	0	0	0	0	6	1	12	6	22	10
Mexico	15	3	0	0	0	0	0	0	0	0
Netherlands	12	1	0	0	0	0	17	5	204	45
Norway	17	4	0	0	0	0	0	0	11	2
Panama	32	6	22	14	22	8	0	0	0	0
Puerto Rico	729	162	822	223	1 339	264	2 138	553	1 735	536
St. Pierre and Miquelon	2	1	0	0	0	0	209	38	0	0
Saudi Arabia	2 937	967	912	269	77	20	576	217	300	55
Singapore	0	0	0	0	15	6	16	7	64	26
South Africa	270	57	397	150	321	81	299	59	300	68
Taiwan	19	8	0	0	24	6	0	0	108	37
Trinidad - Tobago	0	0	89	39	63	51	46	15	30	19
United Kingdom	0	0	19	5	0	0	0	0	3 426	960
United States	374 760	65 236	436 845	76 818	422 937	78 446	499 608	101 574	434 811	93 279
Venezuela	11	1	0	0	0	0	0	0	0	0
Virgin Islands	9	4	0	0	11	6	0	0	0	0
Total	396 883	70 391	460 600	82 203	446 521	81 667	535 003	109 952	477 345	103 216

Source: Statistics Canada.
^{P} Preliminary; ^{r} Revised; - Not reported.

TABLE 5. PRIMARY DESTINATIONS FOR CANADIAN PEAT DELIVERIES FROM MAJOR PRODUCING REGIONS IN 1985

	Canadian Producing Region		
Destinations	Western Canada[1]	Central Canada[2]	Atlantic Canada[3]
		(tonnes)	
Western Canada[1]	18 320	0	140
Central Canada[2]	0	66 090	31 400
Atlantic Canada[3]	0	0	5 770
Sub-Total, Canada	18 320	66 090	37 310
United States	139 955	235 495	112 550
Japan	0	n.a.	21 335
Other	0	1 190	20
Sub-Total, exports	139 955	236 685	133 905
Total	158 275	302 775	171 215

[1] British Columbia, Alberta, Saskatchewan and Manitoba. [2] Ontario and Quebec. [3] New Brunswick, Prince Edward Island, Nova Scotia and Newfoundland.
n.a. Not available, included in other.

TABLE 6. WORLD PRODUCTION OF PEAT, BY COUNTRY, 1982-86

Country	1982	1983	1984r	1985P	1986e
			(000 tonnes)		
Agricultural use					
U.S.S.R.e	180 000	180 000	180 000	180 000	190 000
West Germany	1 841	1 868	1 428	1 515	1 680
United States	724	638	715	750	805
Canada	487	529	500	645	590
Netherlandse	400	400	450	450	400
Francee	120	110	225	200	220
Polande	200	200	200	200	200
Finlandr	577	275	260	200	200
Ireland	95	95	95	95	95
Hungarye	70	70	70	70	70
Swedenr	60	60	60	40	60
Spain	60	40	55	55	50
Denmark	34	30	30	40	50
Norwayr	30	30	30	30	30
Israel	20	20	20	20	20
Other	1 033	1 135	1 115	1 190	290
Total[1]	185 949	185 594	185 338	185 540	194 760
Fuel use					
U.S.S.R.e	59 862	59 862	55 325	49 890	45 350
Ireland	5 279	6 648	7 932	2 630	3 000
Finland	5 499	3 354	2 712	3 190	3 000
West Germany	253	258	275	270	260
Norwaye	1	1	1	1	1
Other	198	202	215	19	450
Total[1]	71 092	70 325	66 460	56 000	51 800
World total	257 040	255 920	251 797	241 538	246 560

Sources: U.S. Bureau of Mines, Peat, C. Davis, 1986; Energy, Mines and Resources Canada.
[1] Total may not round due to duplication in usage totals.
e Estimated; P Preliminary; r Revised.

Phosphate

G.S. BARRY

Naturally occurring rock deposits are the most common source of phosphorus; other sources are bones, guano, and some types of iron ores that yield by-product basic slag containing sufficient phosphorus to warrant grinding and marketing.

Phosphate rock contains one or more suitable phosphate minerals, usually calcium phosphate, in sufficient quantity for use, either directly or after beneficiation, in the manufacture of phosphate products. Sedimentary phosphate rock, or phosphorite, is the most widely used phosphate raw material. Apatite, which is second in importance, occurs in many igneous and metamorphic rocks.

Phosphate rock is graded either on the basis of its P_2O_5 equivalent (phosphorus pentoxide) or its $Ca_3(PO_4)_2$ content (tricalcium phosphate of lime or bone phosphate of lime - TPL or BPL). For comparative purposes, 0.458 unit P_2O_5 equals 1.0 unit BPL, and 1 unit of P_2O_5 contains 43.6% phosphorus.

Approximately 80% of world phosphorus production goes into fertilizers; other products which require the use of phosphorus include organic and inorganic chemicals, soaps and detergents, pesticides, insecticides, alloys, animal-food supplements, motor lubricants, ceramics, beverages, catalysts, photographic materials, and dental and silicate cements.

In 1987 world phosphate rock production was estimated at 145 Mt, or about 7 Mt higher than in 1986. Comparison with previous years must be done cautiously as for the last two years there was a downward revision of some 5 Mt for production in China. Stocks held by major western world producers were 19.1 Mt at the end of September 1987 compared to 23.5 Mt at the end of September 1986. There were small increases in deliveries from all major phosphate producing and exporting countries except Algeria and Morocco. U.S. companies recorded larger volumes but lower prices for their exports.

In July 1984, Sherritt Gordon Mines Limited, Campbell Resources, Inc. and New Venture Equities Ltd. combined to form a joint venture on two phosphate properties at Cargill and Martison Lake in Ontario. In 1987, Jacobs Engineering Group Inc. and Blue, Johnson and Associates completed a feasibility study for the Ontario Ministry of Northern Development and Mines. The study concluded that the deposit may become the basis for a viable mining operation of approximately 500 000 t/y in the 1990s when supply and demand are in balance and phosphate rock prices have improved substantially.

OCCURRENCES IN CANADA

Known Canadian deposits are limited and fall into three main categories: apatite deposits within Precambrian metamorphic rocks located in eastern Ontario and southwestern Quebec; apatite deposits in some carbonate-alkaline complexes (carbonatites) in Ontario and Quebec; and Late Paleozoic - Early Mesozoic sedimentary phosphate rock deposits in the southern Rocky Mountains. Phosphatic mineralization was also reported in the layered rocks of the Athabasca series.

The deposit of greatest economic significance is the Kapuskasing (Cargill) phosphate deposit, where early studies indicated the presence of about 60 Mt of ore grading 20.2% P_2O_5. It has been determined that the deposit contains higher grade sections totalling 22 Mt grading 27% P_2O_5. The best part of the deposit, contains 6 Mt grading 33% P_2O_5. This ore will need only minor concentration.

Another important carbonatite deposit was discovered in 1982 near Martison Lake north of Hearst, Ontario. Higher grade zones of the deposit contained 57 Mt grading 23% P_2O_5.

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CANADIAN PHOSPHATE INDUSTRY

Phosphate Rock. In 1986, Canada imported 2.39 Mt of phosphate rock. For the first nine months of 1987 imports were only 1.52 Mt. The economic recession in the agricultural sector combined with closures of two phosphatic fertilizer plants were responsible for the low import levels. By the end of 1987 Canada's phosphoric acid capacity declined to 647 300 t P_2O_5.

A little over two-thirds of the phosphate rock is imported for fertilizer production and the remainder for elemental phosphorus.

Since the late-1970s, about 70% of Canada's imports of phosphate rock from the United States has been from Florida. The remainder is from western states. Lately the industry in western Canada has been experimenting with phosphate rock from other sources. On a spot basis, very low world shipping costs made such imports competitive with imports from the United States. A more significant shift of imports away from U.S. suppliers is now a possibility, especially since trials on some raw materials were quite successful.

Belledune Fertilizer, a division of Noranda Inc., produced approximately 164 000 t of di-ammonium phosphate (DAP) in 1987 at its New Brunswick fertilizer plant from rock imported from Florida. The plant was shut in June for about 2 1/2 months for inventory control and maintenance. The plant was converted to the hemihydrate process in 1986. The new process is working very well permitting substantial energy savings. It also results in an excellent DAP product.

Cominco Ltd. produced a total of approximately 205 000 t of phosphatic fertilizers in 1987 (MAP and 16-20-0) from its two plants in British Columbia. Both the Trail and Kimberley plants were shut by a strike from May 9 to August 31, 1987. The Kimberley plant was shut down permanently on September 30, 1987. Cominco's mine in Montana will be the main supplier of rock for the Trail plant.

Sherritt Gordon Mines Limited ran its Fort Saskatchewan plant at a steady rate throughout 1987 using Florida rock.

Esso Chemical Canada operated its large Redwater plant at a steady rate throughout 1987. The company uses mainly Florida phosphate rock but during the year it completed extended studies on rock from Togo. Starting in late 1987 the company will also run extended trials on Moroccan rock.

C-I-L Inc. closed its Lambton phosphoric acid plant permanently in June 1986.

Western Co-operative Fertilizers Limited's (WCFL) Calgary plant produced about 173 000 t of ammonium phosphate fertilizers in 1987, mainly MAP. The Calgary plant ceased operation on an indefinite basis on August 25, 1987. The plant will be mothballed and kept in operational order until there is a major market improvement. The nearby Earth Sciences Inc. plant that recovered uranium from WCFL's phosphoric acid was also closed. WCFL has a 5-year contract to buy ESSO's fertilizers and market it under its own brand.

Three of the remaining operating Canadian phosphate fertilizer plants produce wet phosphoric acid by the dihydrate process in which 28-30% P_2O_5 acid is the principal product and gypsum is the waste product. One plant was converted to a hemihydrate operation.

Elemental phosphorus. Tenneco Canada Inc., ERCO Division, operates two thermal reduction plants in Canada where elemental phosphorus is produced by the smelting of a mixture of phosphate rock, coke and silica. One tonne of phosphorus requires the input of about 10 t of phosphate rock (60 to 67% BPL), 2 t of coke and 3 t of silica. Energy consumption is about 13 000 kWh/t of phosphorus.

Tenneco has plants at Varennes, Quebec with a 22 500 t/y capacity of elemental phosphorus (P_4) and at Long Harbour, Newfoundland with an effective capacity of about 60 000 t/y. The elemental phosphorus production from Long Harbour is in a large part destined for Albright & Wilson, Ltd.'s derivative plants in Europe, with some exports to the Far East. A proportion was sent to Port Maitland, Ontario to supplement supplies from Varennes, Quebec. The Long Harbour plant operated at 65 to 75% of its 60 000 t/y capacity. The No. 2 furnace was operating throughout the year while the No. 1 was completely rebuilt over a period of about three months in the later part of 1987. The Varennes plant in Quebec operated at approximately 80% of its 22 500 t/y capacity. The two main electrical furnaces operated at a steady but reduced rate. The four small by-product "mud" furnaces operated with good results.

The two Tenneco phosphorus plants use about 500 000 t of Florida phosphate rock annually. Since the low-grade phosphate rock acceptable for thermal reduction cannot be used by the fertilizer industry, it can be purchased at relatively lower prices (per P_2O_5 unit value). In 1987, some Tunisian rock was imported on an experimental basis.

The elemental phosphorus produced at Varennes is shipped to two Tenneco plants, one at Buckingham, Quebec and the other at Port Maitland, Ontario. At Buckingham, about 9 000 t/y of P_4 is used to produce technical and food grade phosphoric acid (95% H_3PO_4) and 1 000 t/y to produce amorphous red phosphorus.

Tenneco's Port Maitland plant operates on phosphorus from Varennes and Long Harbour, using between 13 000 and 14 000 t/y.

Coproducts of elemental phosphorus are ferrophosphorus, carbon monoxide and calcium silicate slag. Ferrophosphorus contains 20 to 25% phosphorus and is used by the steel industry as a direct source of phosphorus needed for producing certain types of steel.

Phosphate fertilisers. Six of the operating Canadian plants produce wet phosphoric acid by the dihydrate process in which 28 to 30% P_2O_5 acid is the principal product and gypsum the waste product. One plant was converted to a hemihydrate operation in 1986. At present, there is no use for the gypsum and it accumulates in large settling ponds.

Canadian dihydrate phosphoric acid plants are designed to operate on phosphate rock which grades between 69 and 72% BPL (31.1 to 33.0% P_2O_5). The first stage of acid production, which is digestion and filtration, produces "filter acid" grading 28 to 30% P_2O_5. This product is then upgraded by evaporation to about 40 to 44% acid for most in-plant uses, or to 52 to 54% P_2O_5 for commercial sales or specialized uses. The evaporation step is energy intensive and the provenance of sulphuric acid has a bearing on energy consumption. Plants using elemental sulphur as the source of in-plant sulphuric acid production have their evaporation energy requirements met by heat generated in the sulphuric acid plants, since the process is exothermic, (i.e., 1 t of sulphur has a BTU content equivalent to about two barrels of oil). Plants using commercial sulphuric acid, (e.g., produced from SO_2 smelter gases) have to generate vapour requirements with natural gas or coal-fired boilers. To balance energy requirements, an efficient dihydrate WPA plant could theoretically operate using elemental sulphur for 70 to 75% of its requirements and purchase sulphuric acid for the remainder.

Total Canadian phosphoric acid operating capacity at the end of 1987 was 647 300 t/y (100% P_2O_5 equivalent). A plant of some 86 700 t/y of capacity was closed in Kimberley, B.C. in 1987 and will be dismantled; another with 140 000 t/y of capacity in Calgary, Alberta, is being mothballed.

Efficient plants can consistently operate at 90 to 95% nameplate capacity. Most Canadian plants gauge their annual production levels to corporate marketing strategies and fertilizer demand forecasts. At times when agricultural demand is low, Canadian production capacities are seriously underutilized. The recovery of P_2O_5 from phosphate rock, i.e. the efficiency of conversion, varies from 88 to 94%.

All phosphoric acid plants in Canada are integrated to produce phosphatic fertilizers, mainly ammonium phosphates. Ammonium phosphates are produced by a neutralization reaction of phosphoric acid with ammonia and, depending on the proportions of the original constituents, either diammonium phosphate (DAP) (18-46-0) or monoammonium phosphate (MAP) (range from 11-48-0 to 11-55-0) are produced. Another common grade particularly in the west is the 16-20-0.

PRICES

Most phosphate rock is purchased at prices negotiated between consumers and producers which differ from listed prices in consideration of volume, transportation conditions and local competitive conditions. The average unit price of phosphate rock sold or used in the United States for domestic consumption was US$21.11/t f.o.b. mine in the fertilizer year ending June 30, 1987 and that of exported rock was US$23.78/t. This is a considerable drop from an export price of US$27.50/t the previous year.

OUTLOOK

The outlook for 1988 is for a continuation of demand at the current low levels, ample supply and prices that will improve moderately from the abnormally low levels reached in 1987. Significant price improvements will not occur until supply and demand approach a balance, which may not be before the 1990-92 period. A leading consulting firm forecasts a rapid increase in price after that interval to approximately US$45/t in 1995 (basis 70% bone phosphate of lime) from the current US$24.00/t f.o.b. vessel Tampa. At such prices a deposit such as Cargill could become a viable development.

TABLE 1. CANADA, PHOSPHATE ROCK IMPORTS, 1985-87, AND CONSUMPTION, 1984-87

	1985		1986		1987P	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Imports						
United States	2 579 871	109 620	2 287 453	94 971	1 622 671	59 626
Togo	35 800	2 336	36 722	2 645	257 930	12 423
Morocco	22 000	437	63 580	1 921	72 624	719
Tunisia	-	-	-	-	15 000	222
Total	2 637 671	112 413	2 387 755	99 537	1 968 225	72 990

	1984	1985	1986	1987[e]
	(tonnes)			
Consumption[1]				
Eastern Canada	1 213 942	971 041	837 651	688 000
Western Canada	2 053 456	1 767 346	1 519 241	1 246 267
Total	3 267 428	2 738 387	2 356 892	1 934 267

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Available data as reported by consumers.
P Preliminary; [e] Estimated; - Nil.

TABLE 2. CANADA, PHOSPHATE FERTILIZER SHIPMENTS, 1981-87[1]

	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87
	(tonnes P_2O_5 equivalent)					
Domestic markets:						
Atlantic provinces	26 261	29 443	24 965	26 894	20 360	(
Quebec	34 915	43 308	37 835	27 990	23 865	(60 940[2]
Ontario	71 033	71 959	79 160	52 843	39 287	(
Manitoba	75 239	81 907	90 529	92 092	90 354	77 856
Saskatchewan	144 998	153 784	195 170	182 017	184 306	163 352
Alberta	152 906	157 010	161 185	170 943	153 523	132 087
British Columbia	8 998	10 970	11 311	11 940	10 951	10 056
Total Canada	514 350	548 381	600 155	564 719	522 646	444 297
Export markets:						
United States	141 411	82 478	65 790	71 403	46 763	51 344
Offshore	20 305	715	4 652	12 743	17 021	9 427
Total exports	161 716	83 193	70 442	84 146	63 784	60 771
Total shipments	676 066	631 574	670 597	648 865	586 430	505 071

Source: Canadian Fertilizer Institute.
[1] Fertilizer year: July 1 to June 30; not 100% industry coverage. [2] Atlantic provinces, Quebec and Ontario now disclosed as total only.
Note: Totals may not add up due to rounding.

TABLE 3. CANADA, PHOSPHATE FERTILIZER PLANTS

Company	Plant Location	Annual Capacity (tonnes P_2O_5 equivalent)	Principal End Products	Source of Phosphate Rock	Basis for H_2SO_4 Supply for Fertilizer Plants
Eastern Canada					
Belledune Fertilizer div. of Noranda Inc.	Belledune, N.B.	150 000	am ph	Florida	SO_2 smelter gas and waste acid
		150 000			
Western Canada					
Cominco Ltd.	Kimberley, B.C.	(86 700)[1]			
	Trail, B.C.	77 300	am ph	Utah, Montana	SO_2 smelter gas
Esso Chemical Canada	Redwater, Alta.	370 000	am ph	Florida	Sulphur
Sherritt Gordon Mines Limited	Fort Saskatchewan, Alta.	50 000	am ph	Florida	Sulphur
Western Co-operative Fertilizers Limited	Calgary, Alta.	(140 000)[2]	am ph	Idaho Florida	Sulphur
		497 300			
Canada:					
installed capacity:					
end of 1987		647 300			
historical installed capacity:					
end of 1983		1 031 000			
end of 1984		913 000			
end of 1985		788 000			
end of 1986		734 000			
end of 1987		647 300			

P_2O_5 equivalent - Phosphorus pentoxide equivalent; am ph Ammonium phosphates.

[1] Shut down as of the end of September 1987. [2] Shut down and mothballed as of September 1987.

TABLE 4. CANADA, TRADE IN SELECTED PHOSPHATE PRODUCTS, 1985-87

	1985		1986		Jan.-Sept. 1987P	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Imports						
Calcium phosphate						
United States	93 573	33 955	111 208	40 668	82 873	31 929
Other countries	210	264	291	372	425	444
Total	93 783	34 219	111 499	41 040	83 298	32 373
Fertilizers:						
Normal superphosphate, 22% or less P_2O_5						
Israel	1 108	217	-	-	6 300	486
United States	14 001	1 102	190	25	383	78
Total	15 109	1 319	190	25	6 683	564
Triple superphosphate, over 22% P_2O_5						
United States	71 968	14 247	93 285	21 280	52 396	11 417
France	-	-	2 999	728	-	-
Total	71 968	14 247	96 284	22 008	52 396	11 417
Phosphatic fertilizers, n.e.s.						
United States	359 399	94 707	342 315	90 726	269 249	64 928
Belgium-Luxembourg	1 043	578	625	382	746	470
Israel	455	235	131	74	90	57
Netherlands	-	-	-	-	32	15
Other countries	4	8	2	2	5	3
Total	360 901	95 529	343 073	91 184	270 122	65 474
Chemicals:						
Potassium phosphates						
United States	1 495	1 886	3 212	3 242	2 316	2 518
France	234	233	243	291	256	310
Israel	265	241	190	244	157	159
West Germany	46	56	43	66	75	89
Belgium-Luxembourg	-	-	41	40	14	14
Netherlands	34	39	1	2	-	-
Total	2 074	2 456	3 730	3 885	2 818	3 090
Sodium phosphate, tribasic						
People's Republic of China	258	258	405	132	567	157
United States	350	222	336	328	393	248
Netherlands	80	80	148	67	90	49
France	285	90	133	46	71	20
Israel	-	-	-	-	27	2
Belgium-Luxembourg	-	-	45	24	-	-
Sweden	-	-	14	11	-	-
Total	969	973	1 081	610	1 148	476
Exports						
Nitrogen phosphate fertilizers, n.e.s.						
United States	168 006	38 111	133 442	29 683	118 017	24 955
Portugal	-	-	-	-	8 391	1 724
Jamaica	3 410	911	4 153	1 028	7 773	2 049
Australia	-	-	19 936	6 111	-	-
Costa Rica	20	7	10 480	2 449	-	-
Other countries	20	6	135	33	4 213	868
Total	171 456	39 035	168 146	39 304	138 394	29 596

Source: Statistics Canada.
P Preliminary; - Nil; n.e.s. Not elsewhere specified.

TABLE 5. WORLD PHOSPHATE ROCK PRODUCTION, 1983-86

	1983	1984	1985	1986^{e}
	(000 tonnes product)			
WORLD TOTAL	**136 685**	**149 712**	**146 507**	**136 836**
West Europe	**538**	**716**	**734**	**722**
Finland	381	477	510	527
Sweden	107	128	187	192
Turkey	50	96	37	3
France	12	15	-	-
East Europe	**28 500**	**31 900**	**32 200**	**32 500**
U.S.S.R.	28 500	31 900	32 200	32 500
North America	**42 573**	**49 197**	**50 835**	**38 710**
United States	42 573	49 197	50 835	38 710
Central America	**436**	**375**	**549**	**600**
Mexico	436	375	549	600
South America	**3 229**	**3 896**	**4 250**	**4 541**
Brazil	3 208	3 855	4 214	4 509
Colombia	18	28	24	27
Peru	3	13	12	5
Africa	**34 159**	**35 967**	**34 148**	**36 667**
Algeria	893	1 000	1 208	1 203
Egypt	647	1 043	1 074	1 272
Morocco/Sahara	20 107	21 245	20 737	21 178
Senegal	1 522	1 912	1 702	1 746
South Africa	2 742	2 585	2 433	2 859
Togo	2 081	2 696	2 314	2 314
Tanzania	20	15	15	10
Tunisia	6 016	5 346	4 530	5 951
Zimbabwe	133	125	135	134
Asia	**23 529**	**26 662**	**22 276**	**21 568**
China	12 830	11 800^{r}	6 970^{r}	6 700
Christmas Island	1 066	1 259	1 200	825
India	787	800	929	750
Iraq	1 199	1 000	1 000	1 000
Israel	2 969	3 312	4 076	3 673
Jordan	4 749	6 263	6 067	6 249
North Korea	500	500	500	500
Syria	1 229	1 514	1 270	1 606
Vietnam	170	200	250	250
Sri Lanka	15	14	14	15
Oceania	**1 705**	**1 374**	**1 515**	**1 528**
Australia	21	15	7	34
Nauru	1 684	1 359	1 508	1 494

Sources: Phosphate Rock Statistics, 1983, ISMA Ltd.; U.S. Bureau of Mines (USBM), Mineral Commodity Summaries 1985 and 1986.
^{e} Estimated; ^{r} Revised; - Nil.
Note: Totals may not add up due to rounding.

Platinum Metals

G. BOKOVAY

The platinum group metals (PGMs) refer to six closely related metals: platinum, palladium, rhodium, ruthenium, iridium and osmium. These metals, among the scarcest of all metallic elements, commonly occur together in nature.

Prices were extremely volatile during 1987 for platinum and palladium, the most important of the PGMs in terms of both output and diversity of uses. Contributing factors during the first half included weakness of the U.S. dollar, concern over renewed inflation, strong industrial demand and the threat of a miners strike in the Republic of South Africa. Prices deteriorated from September onwards, however, despite continued pressure on the dollar, political volatility in the Middle East and strength of demand from the industrial sector.

The decline of prices was caused to some degree by the growing likelihood of world oversupply for these metals in light of a rash of new mine projects, principally in the Republic of South Africa. This threat of excess supply combined with the appearance of less social unrest within South Africa has had a severe dampening affect on investment demand for platinum in particular. In the last quarter of 1987, speculative demand suffered another reversal following a downturn in the equity markets which raised fears of a recession.

For the remaining PGMs, 1987 was generally unspectacular although rhodium prices strengthened throughout 1987 despite some projections of a downturn in the automotive sector, particularly in the United States. Prices for ruthenium, iridium and osmium, on the other hand, eased somewhat during the year.

Despite the recent softening of PGM prices, encouraging exploration results could enable Canada to significantly increase its share of world production in the next decade.

CANADIAN DEVELOPMENTS

Platinum group metals are produced in Canada by INCO Limited and Falconbridge Limited as by-products from the mining and processing of nickel-copper ores. The bulk of the PGMs are recovered from operations in the Sudbury basin, but small amounts are also produced by INCO at Thompson, Manitoba.

The residue from the refining of nickel-copper matte, which contains platinum group metals, is shipped by INCO to its refinery at Acton in the United Kingdom for the extraction and refining of PGMs. Falconbridge ships a nickel-copper matte containing PGMs to its refinery at Kristiansand, Norway.

Canadian production of PGMs in 1987 is estimated at 13 489 kg, compared to 12 189 kg in 1986. Although a detailed breakdown of Canadian PGM production is not published for reasons of confidentiality, palladium output has been somewhat higher than that for platinum in recent years. By virtue of the size of its nickel mining operations, INCO is by far the largest Canadian PGM producer.

Exploration in Canada for platinum group metals intensified during 1987, stimulated by relatively strong prices, attractive geological potential and a favourable investment climate. One of the most active centers of exploration was the Lac des Îles area near Thunder Bay, Ontario. In July, Madeleine Mines Ltd. announced that it was proceeding with the development of its optioned Lac des Îles deposit, with production scheduled to begin in mid-1988. When fully on-stream, Madeleine expects to be operating at a mining rate of about 2700 t/d. The projected yield from the operation is estimated at approximately 2400 kg/y PGM. The project includes an open pit mine and mill on the site, a hydrometallurgical treatment plant at Thunder Bay and a refinery in Calgary, and is expected to cost $35 million. The company has estimated mining and milling costs of $9.90/t

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of ore and treatment and refining costs of $6.60/t. Estimated reserves in the targeted Roby zone are in excess of 20 Mt grading 6.4 g/t PGM, with a reported platinum to palladium ratio of 1:7, plus 0.69 g/t gold and 0.25% copper-nickel.

Other companies active in the area include American Platinum Inc., Imperial Platinum Corporation, International Platinum Corporation, Cream Silver Mines Ltd. and Equinox Resources Ltd.

Other promising targets in Ontario include the Crystal Lake and Marathon deposits of Fleck Resources Ltd. and the Big Trout Lake platinum property being explored by the "PGM Syndicate", a joint venture involving International Platinum Corporation, Degussa AG and Jenkim Holdings (Canada) Limited. Preliminary test results at Big Trout Lake indicate PGM values of up to 9.6 g/t. International Platinum is also involved in a joint venture exploration project with BP Selco Inc. on the Fox River Sill in northern Manitoba.

Elsewhere in Canada, significant exploration was undertaken in the Labrador Trough. One of the major players, La Fosse Platinum Group Inc., has identified several deposits in the Retty Lake area near Schefferville with PGM values of up to 6.86 g/t. In the Cape Smith Belt of Quebec, Falconbridge Limited, Oasis Resources Inc. and Messeguay Mines Inc. have reported values on their Delta Sill project of up to 7.8 g/t PGM.

In Saskatchewan, the Kasner Group of Companies is involved in several gold-PGM exploration projects in the Beaverlodge area. At Fishhook Bay and at Nicholson Bay, the company has reported exceptional values for gold, platinum and palladium on the basis of preliminary field work. Elsewhere in Saskatchewan, International Platinum is involved in an exploration program at Wiley Lake while Placer Dome Inc. will undertake field work near the site of the former Rottenstone nickel-copper-PGM mine. Placer Dome is also participating in an exploration program with Longreach Resources Ltd. on the "Platinum Blonde" project in the old Franklin Mining Camp near Grand Forks, B.C. PGM exploration is also continuing in the Tulameen area, west of Princeton. Historically, platinum was recovered from gold placer operations on the Similkameen and Tulameen Rivers.

In the Yukon, All-North Resources Ltd. (Galactic Resources Ltd.) and Chevron Minerals Ltd. are conducting an exploration program at the site of the former Wellgreen nickel mine in the Kluane district, 350 km northwest of Whitehorse. An underground exploration program, to be conducted from the old mine workings, has been scheduled. In the Northwest Territories, International Platinum plus Equinox Resources Ltd. in conjunction with Technigen Corporation are involved in exploration programs on the Muskox Intrusion in the Coppermine River area. During 1987, Equinox reported that its preliminary field work had revealed very high grade mineralization.

WORLD DEVELOPMENTS

The major world producers of platinum group metals are the U.S.S.R., the Republic of South Africa, Canada and the United States. Other producers include Japan (from imported nickel and copper ores and intermediates), Colombia, the People's Republic of China, Finland, Australia, Yugoslavia and Zimbabwe. World primary production of PGMs is estimated at about 264 Mg in 1987 compared with 258 Mg in 1986.

The U.S.S.R. derives PGMs principally as by-products of nickel-copper production. For many years, the U.S.S.R. has exported a significant proportion of its PGM production to the western world and is currently the largest supplier of palladium in this market.

It is reported that 85 to 90% of Soviet production is produced from six mines in the Noril'sk region of northern Siberia. The U.S. Bureau of Mines estimates that the PGM content of Noril'sk ores is as follows: 25% platinum, 67% palladium and 8% iridium, rhodium, ruthenium and osmium combined.

The other principal source of PGMs in the U.S.S.R., accounting for about 10% of Soviet production, is the Kola Peninsula where PGMs are a by-product of nickel-copper mining. PGMs are also recovered from placer deposits in the southern Urals, once the major source of U.S.S.R. output. Total Soviet reserves of PGMs are estimated at 6 220 t.

There are three producers in the Republic of South Africa: Rustenburg Platinum Holdings Limited, Impala Platinum

Holdings Ltd. and Western Platinum Limited. Unlike production in Canada or in the U.S.S.R., South African PGMs are derived from ores that are mined primarily for their platinum metal content. South African ores also differ significantly from Soviet mineralization in that they have a much higher ratio of platinum to palladium. The largest portion of South African production comes from ores of the Merensky Reef in the Bushveld igneous complex in the Transvaal. These are reported to contain the following average grades: 3.24 g/t platinum, 1.37 g/t palladium and 0.7 g/t of other PGMs. Merensky ores also contain appreciable quantities of gold, nickel and copper.

Significant PGM reserves also exist in the UG2 (Upper Group Chrome) and Plat Reef zones of the Bushveld complex. While deeper and somewhat more difficult to process, UG2 ore accounts for an increasing share of South African production. It is expected that this trend will continue as easily mined areas of the Merensky reef become exhausted.

The UG2 zone contains significantly more palladium and rhodium but less platinum than the Merensky reef. The breakdown of the average PGM values applicable to the UG2 zone is as follows: 2.46 g/t platinum, 2.04 g/t palladium, 0.72 g/t ruthenium, 0.54 g/t rhodium, and 0.21 g/t iridium and osmium.

Current South African reserves of PGMs, calculated to a depth of 1 200 m, are estimated at 75 000 t. However, a recent report by the Geological Survey of South Africa suggests that PGM reserves in that country may be somewhat larger in view of recent geological studies which indicate that the Bushveld complex extends significantly beyond previously established boundaries.

PGM production was not affected by a widespread strike of mine workers in South Africa during 1987. It is estimated that output increased by approximately 3.3% in 1987, to 124.5 t. At the end of 1987, most mines were thought to be operating at or exceeding full capacity.

Rustenburg, the largest South African producer, operates or controls four mines in the Bushveld complex, namely Rustenburg, Union, Amandelbult and Atok. Capacity of the Rustenburg operations is estimated at 65 300 kg/y PGMs. Rustenburg announced in July 1987 that it will increase production of PGMs in the black homeland of Lebowa. This will be achieved by the development of UG-2 ore on its Maandagshoek holdings as well as an expansion of capacity at the company's subsidiary, Atok Platinum Mines (Proprietary) Limited. When the development is completed the company expects that its Lebowa production will increase to over 1500 kg of PGMs per month. Rustenburg also announced that its expanded Lebowa operations would be renamed Lebowa Platinum Mines Ltd.

PGMs produced by Rustenburg are recovered at the Wadeville refinery in Gemistown, South Africa and another at Royston in the United Kingdom. Both plants are managed by Matthey Rustenburg Refiners (Pty) Limited, which is jointly owned by Rustenburg Platinum and Johnson Matthey Public Limited Company. Rustenburg is currently building a new PGM refinery in Bophuthatswana to replace the Wadeville and Royston facilities. The new plant, which is expected to come on-stream in 1989, will utilize the "Solvex" process which has been successfully utilized in a large-scale pilot plant at the Royston refinery. During 1987, the planned relocation of refinery operations from Wadeville to Bophuthatswana prompted black workers at the former plant to stage four work stoppages. These strikes were all of short duration and did not affect production.

Impala Platinum, South Africa's second largest PGM producer, operates four adjacent mines, namely Bafokeng North and South and the Wildebeestfontein North and South, and a refinery at Springs. The company is thought to have a capacity of about 52 900 kg/y.

In October, Impala announced plans for the development of its new Karee mine near Marikana. The site has about 130 Mt of Merensky ore reserves and 180 Mt of ore reserves on the UG2 reef. The average grade from both zones is estimated at 5 to 5.5 g/t. The company plans to bring the mine on-stream in 1991 at a planned output of 3 100 kg/y increasing eventually to 9 300 kg/y. At least part of the output from the Karee project will be used to offset the anticipated decline in output from Impala's existing operations.

Western Platinum Limited is the smallest South African producer with one mine in the Marikana District of the Transvaal to the east of the Rustenburg operation. PGM capacity of the company's operation is estimated at 8 500 kg/y.

In February 1987, Falconbridge Limited sold its 49% interest in Western Platinum to the company's other principal shareholder, Lonrho plc, for a reported US$75 million. Lonrho has stated that it intends to increase Western's PGM output to approximately 15 000 kg/y. Work on this expansion is reported to be in progress.

In addition to the expansions being undertaken by the three existing South African producers, as many as five additional mines may be developed in the medium term. Northam Platinum Limited, owned 70% by Gold Fields of South Africa Ltd., is proceeding with the development of a new PGM mine southeast of the Amandelbult section of Rustenburg Platinum. It is expected that production will begin in 1991 although the operation will not reach its full design capacity of up to 11 000 kg/y until 1994. The prospect is reported to have reserves totalling 163 Mt grading 10.1 g/t combined PGMs plus gold.

In August, Rand Mines Ltd. and an associated company, Vansa Vanadium S.A. Ltd., announced that they would proceed with the development of their Rhodium Reefs PGM deposit in the eastern Transvaal. The project, which will initially exploit the UG2 reef, is scheduled to commence production in 1992. Output from the mine is expected to be about 10 000 kg/y PGM plus gold during the initial production period, increasing eventually to 15 500 kg/y. Ore reserves at Rhodium Reefs are reported to be 84 Mt on the UG2 grading 6.28 g/t PGMs plus gold. An additional 48 Mt grading 3.9 g/t is contained in Merensky Reef ores at the site.

Another PGM development is that of Lefkochrysos Platinum Ltd., a company associated with Golden Dumps (Proprietary) Limited. The mine, which is to be located near the town of Brits in the western Transvaal, is expected to begin production in 1989 and reach a planned first phase output level of about 8 700 kg/y of PGM by 1990. During the initial production period, mining activity will be restricted to the UG2 zone. UG2 ore reserves at the site are estimated at 125 Mt grading 5.9 g/t PGMs plus gold.

Other possible PGM mine developments in South Africa include Messina Ltd.'s project in the northeastern Transvaal and the Severin Platinum project in the eastern Transvaal, adjacent to the Rhodium Reefs deposit. While there has been no official announcement with regard to the expected start-up date or planned size of the former, the Severin mine is scheduled to come onstream in 1991 with initial production expected to be about 4 800 kg/y of platinum.

The Stillwater Mining Company, jointly owned by Chevron Resources Company, Manville Corporation and Lac Minerals Ltd., produced its first concentrate at the Stillwater Complex palladium/platinum mine in Montana in March 1987. On an annualized basis, the operation was initially expected to attain an output of about 780 kg/y of platinum and 2 330 kg/y of palladium. However, in view of a higher than expected mining rate and mill throughput in 1987, it is reported that this target has already been exceeded. The most recent plan for the mine is for a doubling of capacity by 1990 at a cost of about US$30 million.

At present, the concentrate produced at Stillwater is processed by Metallurgie Hoboken-Overpelt SA in Belgium. During 1987, it was reported that the Stillwater partners were considering the construction of a smelter near the mine site at an estimated cost of US$10 million.

With significantly higher prices for platinum metals, exploration in Australia, like Canada, has intensified significantly during 1986 and 1987. It has been reported that there are approximately 60 companies involved in PGM exploration at more than 50 locations in seven major regions. The latter include the Yilgarn, Pilbara and Halls Creek regions in Western Australia, the South Alligator Valley of the Northern Territory, the Broken Hill and Fifield areas of New South Wales and also Tasmania. One of the most promising projects includes the Munni Munni deposit of Hunter Resources Ltd. in the Pilbara area of Western Australia where grades of up to 3.2 g/t PGMs have been reported. In the South Alligator Valley of the Northern Territory, the Coronation Hill gold/platinum deposit is being explored by The Broken Hill Proprietary Company Limited (B.H.P.), Noranda Pacific Limited and EZ Industries Ltd., a subsidiary of North Broken Hill Holdings Ltd. On the basis of preliminary work, the companies have reported grades of 7.72 g/t gold and

1.76 g/t combined platinum and palladium. In the Fifield area of New South Wales, the site of limited PGM production at the turn of the century, Helix Resources NL has obtained values of up to 14 g/t platinum and 1 g/t palladium.

In recent years, the only PGM producer in Australia has been Western Mining Corporation Limited which recovers small quantities of palladium and platinum as a by-product from nickel mining operations. Production in 1986 was estimated at 500 kg.

Other countries where exploration for PGMs is ongoing include New Zealand, Papua New Guinea, Brazil, Zimbabwe and the Republic of Ireland.

RECYCLING

The recovery of PGMs from secondary sources such as used industrial catalysts, electronic scrap and jewelry constitutes an important source of these metals in the western world. The U.S Bureau of Mines estimates that recycling in the United States yielded approximately 35 000 kg in 1986 including 28 000 kg recycled on a toll basis by major consumers.

Spent automobile catalysts represent a growing and potentially significant source of PGMs. With higher metal prices at the end of 1986 and into 1987, it was reported that competition in the scrap industry had intensified for used converters.

A-1 Specialized Services and Supplies Inc., a major U.S. PGM scrap dealer, estimated that the collection of PGMs from used automotive catalysts in that country would increase to approximately 6 000 kg in 1987.

The major recycler of used auto catalysts in the United States is Texasgulf Inc. The company, which operates a PGM recycling facility at Anniston, Alabama, has a rated capacity to handle about 225 t/m of converter units. However, it has been reported that Texasgulf has operated the plant at a rate of over 315 t/m.

PRICES

Platinum

Platinum prices, which averaged US$518.86/oz. in London during January 1987, increased through the first part of the year due to the extreme weakness of the U.S. dollar, the threat of a renewed round of inflation and strong industrial demand. Platinum reached a high for the year of $646.50 on April 27. Prices softened somewhat in June, averaging $569.00, but recovered in August reaching $633.00. This second peak was caused primarily by unrest in the Middle East and the threat of a mineworkers strike in South Africa. With the avoidance of any labour disruption at South African platinum mines, combined with the threat of future oversupply and then followed by heightened fear of a recession after the stock market plunge in October, platinum prices were generally lower during the remainder of 1987. The average price of platinum in December was $500.30. The average London price for platinum in 1987 was $555.95 compared with $464.92 in 1986.

Palladium

For almost identical reasons palladium price movements during 1987 mirrored those for platinum almost step for step. From an average price of US$123.41 in January the price of palladium increased during early 1987 to reach a high for the year of US$161/oz. on April 27. Palladium prices eased somewhat in June but staged a moderate recovery in early August, reaching $147.75. Prices for the remainder of the year were generally lower. The average price of palladium in December was $120.30. The average price of palladium during 1987 was $131.40 compared with $117.00 in 1986.

Other PGMs

The lesser known PGMs - rhodium, ruthenium, iridium and osmium - are produced in relatively small amounts. Collectively, this group constitutes about 15% of South African PGM production and about 10% of Canadian output. Unlike platinum and palladium which are principal products in South African production, the other PGMs are all by-products and their supply is essentially inelastic. With substantial quantities of these metals being sold directly by producers to consumers, the open market is often characterized by thin trading and exaggerated price movements.

Speculative demand for rhodium, whose principal use is in automobile catalysts to control nitrous oxide emissions, has remained quite strong during the past several years in anticipation of the introduction of emission regulations within the European Economic Community, beginning in 1988. This strength is also attributable to the fact that the ratio of platinum to rhodium in "three way" automobile catalysts may be as high as 5:1 compared with a Merensky ore ratio in South Africa of 20:1. Unlike platinum and palladium there was a significant improvement of rhodium prices during the course of 1987 and also much less volatility. Rhodium prices began the year at about US$1100/oz. but increased to about $1250 at the end of 1987.

There was some erosion of prices of ruthenium, iridium and osmium during 1987. Ruthenium prices, which began the year in the $75-$80/oz. range, fell to $67-$71 while iridium prices fell from about $400 to $340. Prices for osmium, the rarest member of the PGM group, slipped from a trading range of US$650-750/oz. at the beginning of 1987, to $590-$650 at year end.

USES

Platinum group metals are used in a wide variety of applications in pure form and in a host of alloys combining different PGMs alone or with other metals. The diversity of uses reflects their varied and unique attributes which include chemical inertness and corrosion resistance, special magnetic properties, stable catalytic and thermo-electric properties, excellent reflectivity, stable electrical contact resistance and good high temperature oxidation resistance. The major uses of PGMs are in the automotive, jewelry, chemical, electrical, petroleum and glass industries.

One of the largest uses for PGMs, particularly platinum, is in the production of automobile catalysts. Auto catalysts designed to control nitrous oxides as well as carbon monoxide and hydrocarbons, contain rhodium as well as platinum and palladium.

The largest market for automotive catalysts is the United States but the adoption of automobile emission standards across Europe will provide a significant boost to platinum demand. Emission control standards have already been adopted by Austria, Sweden and Switzerland. Pollution standards on all newly-designed car models in the European Economic Community (EEC) with an engine displacement larger than two litres are scheduled for implementation in October of 1988. Standards for cars with smaller engine sizes are scheduled to be phased in during the early 1990s. Automobile manufacturers have the option of meeting emission requirements on the smaller engines through a variety of means, including the so-called "lean burn" engine technology, but it is expected that most will utilize some form of PGM catalyst.

Even before the actual adoption of emission standards in the EEC, demand for converter equipped automobiles has increased dramatically. It was reported that in West Germany, 35% of new cars sold during the first half of 1987 were equipped with these devices.

The production of lead-free gasoline, which is required to avoid poisoning of autocatalysts, also uses PGM catalytic agents. Moreover, the injection of platinum into the combustion chamber of automobile engines is reported to increase fuel efficiency by up to 22%. In the refining industry, PGM catalysts are used in hydrocracking and isomerization applications.

The use of PGMs in jewelry, which constitutes the second most important use for platinum, is particularly large in Japan and has also been growing in Europe, especially in the Federal Republic of Germany. Despite higher dollar prices, the steady appreciation of the yen has allowed the demand for platinum jewelry in Japan to remain strong.

In the chemical industry, PGMs are widely used as catalysts with the most important being platinum, ruthenium and palladium. Important specific applications include the production of nitric acid and hydrogen cyanide. PGMs are also used in the manufacture of equipment that is exposed to highly corrosive environments including anodes used in electrolytic processes for such products as chlorine and caustic soda.

The largest market for palladium is in the electronics industry where it is used in the manufacture of multi-layer chip capacitors, resistor networks and electrical contacts. The second most important application and fastest growing market for palladium is in the field of dentistry, where it is used in dental alloys and orthodontic and prothodontic devices. Much of this growth has resulted from the substitution of palladium for higher-priced gold. In the medical field, PGMs are used for a variety of products including hypodermic needles, electrodes, casings for pacemakers and as essential ingredients for certain pharmaceuticals such as cisplatin and the new paraplatin which are effective in the treatment of certain cancers.

Other important applications for PGMs include: thermocouples used for high temperature measurement; the manufacture of glass, glass fibre and synthetic fibres; permanent magnets; and catalytic applications in the pharmaceutical and food processing industries.

One potential use, which could represent a major new market for platinum, is in the production of fuel cells. In this regard, it has been suggested that 13% of Japanese electricity requirements could be provided by such cells by the year 2000.

In addition to uses by industry or in the manufacture of jewelry, there has been a rapid increase in the production of platinum coins, wafers and small bars in recent years in response to growing investment demand. The one ounce Isle of Man noble, first introduced in 1983, is the most important platinum bullion coin currently being produced in the world. In 1987, it was reported that the Republic of South Africa issued its first legal tender one ounce platinum coin to mark the tenth anniversary of the creation of the black homeland of Bophuthatswana.

OUTLOOK

In spite of the potential volatility of the political situation in South Africa and continued strong industrial demand, it is expected that a climate of economic uncertainty and reduced speculative demand will continue to exert some downward pressure on PGM prices in the short-term. In the case of platinum, it is anticipated that prices should remain at US$400/oz. or higher.

Notwithstanding some increases in capacity, particularly in South Africa, the longer term outlook for platinum is positive with a 3.0 to 3.5% average annual rate of growth in demand predicted for the next decade. The major growth areas will continue to be the autocatalyst market, particularly in Europe, and also jewelry. Demand from the investment sector is expected to recover but this market will continue to be somewhat erratic. In view of the significant erosion of platinum premiums over gold during 1987, it would appear that investors still regard gold as a superior store of value.

Demand for palladium in the important electronics sector, which increased significantly in 1987, should continue to grow in 1988. A new palladium-based connector coating, which permits manufacturers to significantly reduce gold usage in electronic applications, had opened up enormous new market opportunities for palladium. In addition, the large market for palladium in dentistry should also continue to expand. Therefore, it is expected that palladium demand will match the 3.0-3.5% annual growth rate expected for platinum during the next decade.

New and stricter environmental controls on automobile emissions of nitrous oxides in the next decade will keep rhodium prices at or near recent highs despite efforts to increase the efficiency of rhodium utilization. In this regard, it is reported that autocatalyst manufacturers are striving to increase the platinum:rhodium ratio in three-way catalysts from 5:1 to at least 10:1.

Canada appears to have significant potential with regard to platinum metals but it is expected that the industry will be developed along lines which bear little resemblance to that established within South Africa. Although reserves in the Bushveld Complex are extremely large in comparison to deposits being discovered in Canada, the thinner Bushveld deposits such as the Merensky Reef would be uneconomic in this country. Mining thicknesses, in some cases of less than one metre, inhibit the mechanization of operations. For this reason and the fact that many Canadian prospects contain relatively high palladium to platinum ratios, only high grade deposits amenable to low cost bulk mining methods are expected to be developed in this country.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
CANADA					
36300-1	Platinum wire and platinum bars, strips, sheets or plates; platinum, palladium, iridium, osmium, ruthenium and rhodium, in lumps, ingots, powder, sponge or scrap	free	free	free	free
48900-1	Crucibles of platinum, rhodium and iridium and covers therefore	free	free	15	free
UNITED STATES (MFN)					
601.39	Precious metals ores		free		
605.02	Platinum metals, unwrought, not less than 90% platinum		free		
605.03	Other platinum metals, unwrought		8.2		
605.05	Alloys of platinum, semi-manufactured, gold-plated		10.0		
605.06	Alloys of platinum, semi-manufactured, silver-plated		6.5		
605.08	Other platinum metals, semi-manufactured, including alloys of platinum		8.2		
644.60	Platinum leaf		8.2		

Sources: Customs Tariff, 1987, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1987), USITC Publication 1910; U.S. Federal Register, Vol. 44, No. 241.

TABLE 1. PLATINUM METALS, PRODUCTION AND TRADE, 1985-87

	1985		1986		1987P	
	(kilograms)	($000)	(kilograms)	($000)	(kilograms)	($000)
Production[1]						
Platinum, palladium, rhodium, ruthenium, iridium	10 534	..	12 189	..	13 489	..
Exports						
Platinum metals in ores and concentrates					(Jan.-Sept.)	
United Kingdom	7 083	51 574	9 041	97 693	4 761	60 329
Total	7 175	52 171	9 063	98 196	4 786	60 575
Platinum metals, refined						
United States	4 286	29 423	2 126	21 170	660	4 020
United Kingdom	1 363	8 091	1 413	8 996	2 070	12 504
Total	5 772	38 480	3 594	30 697	2 848	18 285
Platinum metals in scrap						
United States	1 182	15 880	5 072	12 278	5 724	20 996
United Kingdom	1 854	15 563	489	3 906	84	498
West Germany	22	125	0	0	236	3 694
Total	3 058	31 568	5 670	17 300	6 075	25 986
Imports						
Platinum lumps, ingots, powder and sponge						
United States	23	291	486	9 904	514	12 156
United Kingdom	105	1 430	292	5 543	93	2 069
Total	129	1 736	782	15 490	667	14 225
Other platinum group metals						
United States	220	1 022	539	4 874	348	3 214
United Kingdom	118	1 480	439	3 440	297	2 542
Total	338	2 502	978	8 314	705	8 643
Platinum crucibles[2]						
United States	623	12 674	666	20 001	416	13 079
Total	629	12 765	666	20 001	416	13 079
Platinum metals, fabricated materials						
United Kingdom	107	1 472	368	6 103	105	2 272
United States	810	4 102	1 103	6 663	447	4 774
West Germany	19	212	27	170	0	0
Total	935	5 786	1 783	18 345	578	7 349

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Platinum metals, content of concentrates, residues and matte shipped for export. [2] Includes spinners and bushings.

P Preliminary; .. Not available.

TABLE 2. ESTIMATED WORLD PRODUCTION OF PLATINUM GROUP METALS, 1981-87

	1981	1982	1983	1984	1985	1986	1987
				(tonnes)			
U.S.S.R.	104.2	108.9	112.0	115.0	118.2	119.7	119.7
Republic of South Africa	96.3	98.8	101.7	115.8	119.0	120.5	124.5
Canada	11.9	7.1	7.0	10.4	10.5	12.2	13.5
Others	4.9	5.1	5.3	6.0	6.0	6.0	6.0
Total	217.3	219.9	226.0	247.2	253.7	258.4	263.7

Sources: U.S. Bureau of Mines and Energy, Mines and Resources Canada.

TABLE 3. PLATINUM SUPPLY AND DEMAND, WESTERN WORLD, 1982 AND 1986

	1982	1986
	(000 grams)	
Supply		
South Africa	60 962	73 092
Canada	3 732	4 665
Others	933	1 244
	65 627	79 002
U.S.S.R. sales	11 819	9 020
Total	77 446	88 021
Demand		
Western Europe	10 264	14 618
Japan	32 658	31 414
North America	22 083	37 013
Rest of western world	7 154	5 288
	72 159	88 333
Western sales to COMECON/China	933	1 244
Movements in stocks	4 354	(1 555)
Total	77 446	88 021

Source: Johnson Matthey Public Limited Company.
Note: Totals may not add due to rounding.

TABLE 4. PALLADIUM SUPPLY AND DEMAND, WESTERN WORLD, 1982 AND 1986

	1982	1986
	(000 grams)	
Supply		
South Africa	25 504	32 347
Canada	4 976	5 910
Others	2 177	2 799
	32 658	41 056
U.S.S.R. sales	48 210	49 765
Total	80 868	90 821
Demand		
Western Europe	10 886	16 796
Japan	27 682	38 257
North America	26 749	30 014
Rest of western world	5 288	5 443
	70 604	90 510
Movements in stocks	10 264	311
Total	80 868	90 821

Source: Johnson Matthey Public Limited Company.
Note: Totals may not add due to rounding.

TABLE 5. PLATINUM DEMAND BY APPLICATION, 1982 AND 1986

	1982	1986
	(000 grams)	
Western world		
Auto	20 062	32 658
Chemical	8 087	6 065
Electrical	5 288	5 599
Glass	2 644	2 799
Investment	1 400	13 996
Jewellery	23 794	26 438
Petroleum	2 022	622
Other	8 864	156
Total	72 159	88 333
Japan		
Auto	5 288	7 776
Chemical	311	467
Electrical	622	1 400
Glass	1 400	933
Investment	-	1 089
Jewellery	19 284	23 016
Petroleum	467	-
Other	5 288	(3 266)
Total	32 658	31 414
North America		
Auto	14 152	20 528
Chemical	2 488	2 022
Electrical	2 177	2 022
Glass	311	778
Investment	1 244	9 331
Jewellery	467	467
Petroleum	622	311
Other	622	1 555
Total	22 083	37 013
Rest of western world including Europe		
Auto	622	4 354
Chemical	5 288	3 577
Electrical	2 488	2 177
Glass	933	1 089
Investment	156	3 577
Jewellery	4 043	2 955
Petroleum	933	311
Other	2 955	1 866
Total	17 418	19 906

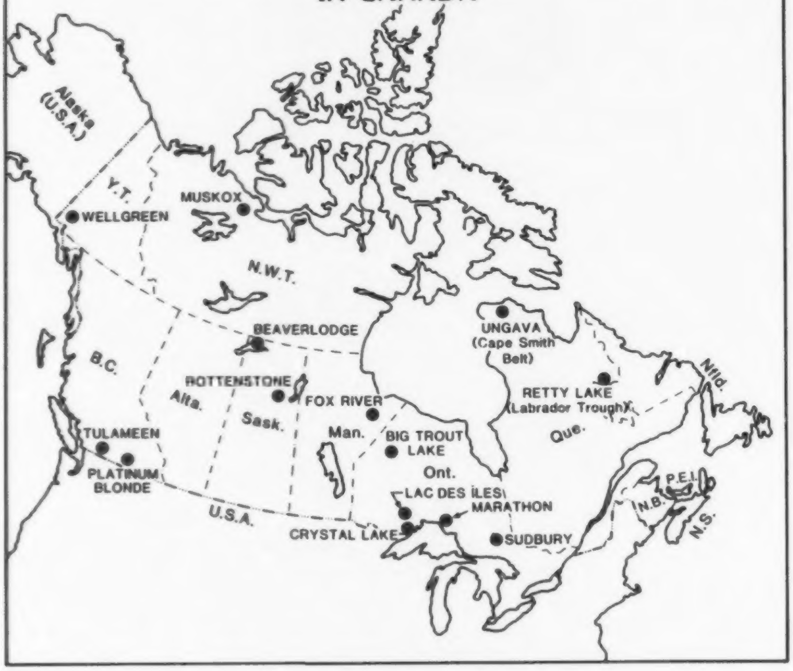
Source: Johnson Matthey Public Limited Company.
- Nil.
Note: Totals may not add due to rounding.

TABLE 6. PALLADIUM DEMAND BY APPLICATION, 1982 AND 1986

	1982	1986
	(000 grams)	
Western world		
Auto	9 020	6 998
Dental	18 351	28 770
Electrical	26 127	41 056
Jewellery	6 843	5 288
Other	10 264	8 398
Total	70 604	90 510
Japan		
Auto	4 976	2 488
Dental	5 910	8 709
Electrical	12 130	23 327
Jewellery	1 866	2 177
Other	2 799	1 555
Total	27 682	38 257
North America		
Auto	4 043	4 043
Dental	8 087	11 664
Electrical	9 953	10 264
Jewellery	311	311
Other	4 354	3 732
Total	26 749	30 014
Rest of western world including Europe		
Auto	-	467
Dental	4 354	8 398
Electrical	4 043	7 465
Jewellery	4 665	2 799
Other	3 110	3 110
Total	16 174	22 239

Source: Johnson Matthey Public Limited Company.
- Nil.
Note: Totals may not add due to rounding.

SELECTED PLATINUM GROUP METAL PROPERTIES IN CANADA


Alaska (U.S.A.)
Y.T.
WELLGREEN
MUSKOX
N.W.T.
BEAVERLODGE
B.C.
ROTTENSTONE
FOX RIVER
Alta.
Sask.
Man.
TULAMEEN
PLATINUM BLONDE
BIG TROUT LAKE
Ont.
U.S.A.
LAC DES ILES
MARATHON
CRYSTAL LAKE
SUDBURY
UNGAVA (Cape Smith Belt)
RETTY LAKE (Labrador Trough)
Que.
Nfld.
P.E.I.
N.B.
N.S.

Potash

G.S. BARRY

SUMMARY

World production of potash in 1987 is estimated at 28.6 Mt (K_2O equivalent). Demand was higher by some 0.3 to 0.5 Mt resulting in a decline in inventories.

Production of potash in Canada in 1987 was estimated at 7.3 Mt, 5% higher than in 1986. Shipments from mines were also higher at 7.45 Mt, while sales estimated from Potash and Phosphate Institute available data were between 7.6 and 7.7 Mt. Producer stocks declined to 1.135 Mt which at current levels of monthly shipments is normal, but could be considered low in times of more buoyant demand.

There was a rebound in potash consumption in Canada and in all our major export markets including marginally in the United States. In the United States, the acreage reduction program continued for the fourth year but is expected to peak in 1987-88. There are also signs of more intense application of fertilizers per acre for key potash intensive crops (up by 5 to 6%) and this trend may continue in 1988.

Prices which were very low in 1986 and at the beginning of 1987, rose slowly throughout the year from US$58-60/t to US$76-82/t f.o.b. Vancouver for standard grade potash. Prices in the U.S. market remained low until mid-year, rose at the start of the new Fertilizer Year and were substantially higher in September as a result of a U.S. antidumping action against Canadian potash producers. Standard grade potash was listed at US$97/short ton at year-end, but the price was reduced to $80/s.t on January 9, 1988 following a suspension agreement on the dumping issue.

The roller coaster price history of Canadian potash since 1970 can best be expressed in terms of unit value of shipments f.o.b. mine as reported by companies to Statistics Canada (Table 9). In "constant 1985 Canadian dollars" the unit value was low, at just over $110/t in the early 1970s; fluctuated at normal levels between $125/t and $160/t from 1974 to 1979; reached a very high peak of $197/t and $191/t in 1980 and 1981; and plunged precipitously to $81/t in 1986. There was a rebound to approximately $95/t in 1987.

In 1987 the world supply-demand imbalance was still in place and overall capacity utilization was just over 80%, principally because Canadian mines operated at an abnormally low level of 67%, while almost all other world producers continued to operate at near optimum levels.

Exports outside North America, referred to as "offshore sales" recorded a large increase of approximately 19% from 2.6 Mt in 1986 to 3.1 Mt in 1987. This followed an even larger increase of 35% already recorded between 1985 and 1986. There was an improvement in practically all major offshore markets; the notable exception was India where Canada lost more than half of its previous market share, mainly because of a drought induced decline in overall demand which affected Canadian exports in particular. Exports to China and Bangladesh tripled; they doubled to Taiwan, the Philippines and New Zealand; they were between 25% and 50% higher to Malaysia, Indonesia, and Australia; they increased to other large traditional buyers like Japan and South Korea and remained at a high level in Brazil.

The western European market continued to grow in importance accounting for approximately 350 000 t K_2O in 1987 compared to only 15 000 t five years ago. This market is open not only to the New Brunswick mines but also to Saskatchewan potash.

CANADIAN DEVELOPMENTS

The average value of potash shipped f.o.b. mines was $91.34/t K_2O in 1987 compared to $81.88/t in 1986. The average export value calculated by Statistics Canada on the basis of port of exit (e.g. Vancouver or Saint John) or border crossing to the United States was $138.04/t K_2O in 1987 (based on 10 months exports) compared to $139.50/t in 1986.

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Over the years, there were significant variations in reported production and export statistics. Table 5 is a reconciliation of such data. Besides reported production variations, the data demonstrates that over a period of 16 years, exports were probably under-reported to Statistics Canada by at least a cumulative 2.0 Mt.

Employment in the Saskatchewan potash industry was estimated at 3520 in 1987 compared to 3574 in 1986. In New Brunswick employment in 1987 was estimated at 854 compared to 826 in 1986.

For short intermittent periods in the summer and fall, all conventional potash mines in Saskatchewan closed for maintenance, vacation, and on a limited lay-off basis. All the conventional mines except one also scheduled closures over the Christmas-New Year period.

Preliminary Principal Statistics for 1986 are now available. They indicate that 31 150 000 t of ore were milled to produce 6 678 000 t of K_2O (10 933 000 t KCl). The average recovered grade was 21.4% K_2O. The recovery of potash from ore was approximately 88%. Ore grades range from 23% to 26% K_2O. One mine is an exception, where the mining practice is to mine two potash beds with the intervening waste which results in lower ore grades. By contrast mines in the U.S.S.R., the world's largest potash producer, extracted between 75 and 80 Mt of ore to produce 9.8 Mt K_2O for an average recovered grade of 12% to 13% K_2O.

Canadian mine production revenue was approximately $564 million in 1986. The cost of all direct inputs was $215 million. The "value added" was therefore $349 million, compared to a record of $899 million established in 1981. Exactly 50% of all input costs were for energy. The industry employed 4313 persons in 1986 with salaries and wages of $147 million. The average wage per employee was $34 013 in 1986 compared to $26 564 in 1981. A total of 3038 persons were employed directly in mining and milling. Productivity per worker was 2 198 t K_2O in 1986, which is 2 to 5 times higher than in any other producing country. For example annual productivity is 400 t K_2O per worker in the U.S.S.R., 679 t in the United States and 1100 t in Israel which is considered the second most efficient potash producer after Canada. It is important to note that because of low capacity utilization in Canada in 1986 the productivity of 2 198 t/worker is lower than the norm. For example in 1984, 7 749 000 t K_2O were produced by 3211 workers for a productivity factor of 2 413 t per employee.

In 1986 the potash industry paid $50.5 million in provincial and municipal taxes and various royalties, and approximately $6.0 million in federal income tax. Taxes due in 1986 were unusually low because of market conditions.

On February 10, 1987, two U.S. potash producers, Lundberg Industries Inc. and New Mexico Potash Corp. filed an anti-dumping petition against Canadian potash producers.

A preliminary determination, by the United States International Trade Commission (ITC), that imports of Canadian potash had caused material injury to the U.S. potash industry was handed down on March 23. The United States Department of Commerce (DOC) determined on August 20, also on a preliminary basis, that Canadian potash had been sold at less than "fair value" in the United States. The DOC then imposed antidumping duties against all Canadian potash producers ranging from 9.14% to 85.2%. The final DOC determination was due on January 8, 1988 and the final ITC determination 45 days later.

Meanwhile, on December 8, Canadian producers agreed to negotiations towards a suspension agreement. These negotiations were completed successfully and a suspension agreement with DOC was signed on January 8, 1988. In entering into this agreement, the Canadian producers did not admit that any exports of potash from Canada have had an injurious effect on U.S. producers. The Canadian producers however did agree to follow pricing practices, under specific formulas, that could not be construed as dumping. DOC will monitor Canadian exports until January 1993 after which this trade dispute will be terminated.

From the beginning the Canadian position was that the case was without merit. DOC's action prompted strong protests from American farm groups and it is doubtful that the case could have resulted in an affirmative final ITC injury determination had the case run its course.

In response to the U.S. action the Saskatchewan government introduced legislation in September 1987 giving the province the right to control the aggregate level of potash produced in Saskatchewan, to allocate quotas to the various producers and to control any future expansion of potash production capacity. Saskatchewan has not yet implemented its legislation but the government now has powers that could be swiftly invoked should the potash market situation justify it.

At the end of 1987, Canadian installed potash production capacity was 9 860 000 t K_2O in Saskatchewan and approximately 1 030 000 t K_2O in New Brunswick for a total of 10 890 000 t K_2O (18 150 000 KCl). The largest share of Canadian capacity, 43.2%, is held by Potash Corporation of Saskatchewan (PCS), a provincial Crown corporation, followed by International Minerals & Chemical Corporation (IMC) with 16.1%, the largest private producer in the western world. In 1987, 630 000 t of capacity in Saskatchewan was lost through flooding.

SASKATCHEWAN

The Potash Corporation of Saskatchewan (PCS) made significant progress during 1987 towards regaining profitability. In 1986 the corporation reported a loss of $103 million, but in 1987 it will be much closer to the break-even point. The five divisions of Potash Corporation of Saskatchewan Mining Limited (PCS Mining) produced approximately 4.3 Mt of potash (KCl) in 1987, compared to 3 601 000 t in 1986.

PCS continued to trim employment which is estimated at about 1480 at the end of 1987, down from 1668 last year. The peak employment of 2267 was reached in 1981. During the first 4 months of 1987, 175 employees were laid off including seven senior executives. During 1987 PCS continued with its policy of closing mines for a few weeks at times of oversupply and for maintenance. All were closed from January 16 to February 3; July 1 to August 18, and August 21 to September 15 (breakdown). Cory was closed May 28 to June 6, June 25 to August 11, and October 25 to November 7. Lanigan was closed January 1 to February 17 (strike) and July 31 to September 15. Rocanville was closed July 12 to August 8. All PCS mines except one were closed on December 20 and one mine will reopen January 4, one on January 17 and one on January 26, 1988.

Expansion of the Lanigan mine was completed by mid-year 1987. The company currently operates the new potash refinery while the older plant will remain closed until overall demand improves.

The Esterhazy Division of PCS Mining, experienced major costs related to flooding problems at the IMC K2 mine since PCS is responsible for 25% of such costs.

PCS Mining operated a 30 000 t/y fertilizer grade potassium sulphate plant at the Cory mine. In 1987 capacity utilization was over 75%. Down periods at this plant corresponded to those for the mine in general, as dictated by KCl production.

The company completed construction of a small 10 t/d industrial grade potassium sulphate plant at Big Quill Lakes. The plant started operation in July and by year end was doing well. The plant uses the ion exchange process to produce a very pure, fine grade industrial product to a specification of 99.7% K_2SO_4 (equivalent to 54.35% K_2O). The company completed a feasibility study on a large, 300 000 t/y plant (fertilizer grade) but a decision on its construction has not yet been made.

The Government of Saskatchewan announced its intention to sell part or all of PCS back to the private sector, but this may not take place until the overall potash situation improves appreciably. Meanwhile, the government made public its intention to write off some $800 million of PCS's debt.

Central Canada Potash (CCP), a subsidiary of Noranda Inc., produced about 800 000 t of potash (KCl) in 1987 which was the same as in 1986. The company closed its Colonsay mine from December 15, 1986 to February 8, 1987. The mine experienced further intermittent closures from July 19 to August 9; September 30 to October 25; October 31 to November 22; and December 20 to January 9, 1988. The September 30 shut-down was due to a failure of the main thickener that had to be repaired. CCP follows a policy of running on a seven day per week schedule while in production. Employment at year-end was about 370.

Cominco Ltd. produced about 950 000 t KCl in 1987 compared to 896 000 t in 1986. The company closed its Vanscoy mine from December 14, 1986 to February 1, 1987. The mine was closed again from June 29 to August 3 and from December 20 to January 3, 1988. While in operation the mine is run on a seven day per week basis to reduce unit costs. Employment at year-end was about 365.

The Vanscoy mine is run very efficiently. It is the deepest potash mine in Saskatchewan; it experiences more severe ground control problems than other mines. Fortunately the potash beds there are largely overlain by a relatively dry Dawson Formation.

The International Minerals & Chemical Corporation (IMC) operates two mines near Esterhazy, Saskatchewan. K1 and K2 which are connected underground. In 1987 IMC produced almost 3.5 Mt KCl of which about 28% was on PCS's account. The mines were closed from December 24, 1986 to January 7, 1987; from June 28 to July 12 and again from December 20 to January 2, 1988. Employment at the Esterhazy operations was approximately 810 in 1987 compared to 815 at the end of 1986. Currently there is an additional 140 employed on water related problems.

The K2 mine is still experiencing the water problems which started in December 1985. During 1987 chemical grouting with a solution of calcium chloride continued successfully and resulted in decreasing the water inflow to a more manageable level of between 500 and 1000 gallons per minute. Pressure in the overlying water bearing Dawson Formation rose to about 1070 psi which is about 85% of normal formation pressures. The company drilled and installed a drop pipe from the surface to the inflow area and backfilled much of the existing cavities with waste salt. This will have the effect of reducing local subsidence. The company is also experimenting with underground bulkhead construction to determine whether the entire area prone to water inflows could be sealed off if necessary. Most of the water stored in the mine was pumped out and injected into deep wells. Access to a mining machine cut off since 1985 was achieved near year end; it is being rebuilt.

In the Annual Report covering the period to June 30, 1987 the company indicated that water inflow insurance claims receivable were US$51.9 million. PCS also paid its share of the costs which is 25%. Together with expenditures incurred to the end of 1987 the costs of the water inflow now surpass C$100 million.

The company is not yet certain that the inflow can be completely stopped. Currently, it is conducting additional seismic tests to help in long term mining decisions. It is presumed that in 1988 water control will continue to rely mainly on calcium chloride injection.

Kalium Chemicals, a division of PPG Canada Inc. was sold to Sullivan and Proops (S&P) of Chicago, U.S.A. The company will operate in Canada under S & P Canada II, Inc. The transaction comprised all of the Canadian potash assets as well as the Michigan deposit. The price, as reported by outside sources was in the vicinity of US$160 million.

During 1987 the company completed its expansion program at the Belle Plaine mine to reach a rated capacity of 1.245 Mt K_2O (2.2 Ms.t. of 62.3% K_2O product). However since markets remained oversupplied in 1987, the company elected to operate at former capacity levels for the remainder of the year, producing somewhat below 1.0 Mt K_2O. This could be achieved through the intermittent operation of two lines of production.

Kalium started disposal of waste salt in underground cavities in 1979; in 1987 the disposal rate increased to almost 100% of daily production. Soon salt additions to the above ground tailings pile will be made on an emergency basis only. In a potash solution mine, energy is the largest component of production costs. Natural gas deregulation in 1987 allowed Kalium (and other conventional mines) to buy 65% of their requirements on the open market and 35% from the Saskatchewan Power Corporation (SPC). This formula introduced substantial cost saving opportunities.

In 1987 the Kalium mine had approximately 317 employees, which included contract workers. Starting in 1988 the company will move its head office from the United States to Regina, Saskatchewan.

Potash Company of America, Inc. (PCA) in which Rio Algom Limited held an 87.8% interest to year-end, closed its Patience Lake mine on an indefinite basis in February 1987 due to flooding. All of the underground equipment was brought to surface by March 3, 1987 and the bottoms of the two shafts were sealed with concrete from March to June. The mine produced less than 50 000 t KCl in the beginning of the year but had an additional 200 000 t to sell from inventories. Thereafter PCA contracted to buy potash from PCS for its U.S. customers and offshore commitments.

The mine normally employed about 300, but this number was over 400 before closure as additional workers were hired to fight the water inflow. After June the work force was reduced to about 30.

During 1987 the company examined various options to reactivate the mine. A conventional method that would have made use of the sealed shafts was set aside, in preference to solution mining. By September it was decided to proceed with a pilot solution mining project. A pair of intake/outlet brine wells was drilled by December and a potash precipitation pond of 13 acres was prepared on a former brine pond. The method will use the principle of natural precipitation of KCl from a hot saturated brine as it is cooled in the winter environment. By April 1988 it is hoped to have a sufficient amount of precipitate for "harvesting" and processing in the existing flotation plant. If all goes well up to 60 000 t of product could be obtained next year from this experimental campaign. Subsequently if PCA decides to proceed to full production, a capacity of at least 500 000 t could possibly be put in place. At the experimental stage employment will vary from 30 to 60.

In November 1987 Rio Algom Limited announced that it will amalgamate PCA into the corporation. The amalgamation required the concurrence of PCA's preferred shareholders who at the beginning of 1987 refused a low offer but eventually settled for the equivalent of about $18 per share in cash or Rio Algom common shares. Regulatory approvals for the amalgamation were received by year-end.

Saskterra Fertilisers Ltd., a wholly owned subsidiary of Canterra Energy Ltd. of Calgary owns 40% of the Allan potash mine (60% PCS). In 1987 Saskterra's share of production amounted to about 350 000 t KCl. Saskterra continued to market its potash in the United States through Texasgulf Inc. to mid-1987 and thereafter by the International Commodities Export Corporation (ICEC). Its offshore tonnage was sold through Canpotex Limited until the end of the year; starting January 1, 1988, it will market exclusively through ICEC. Canadian sales are handled by Sylvite Sales Inc.

MANITOBA

Canamax Resources Inc. and the Manitoba government formed Manitoba Potash Corporation (MPC) in which Canamax holds a 51% interest and the Manitoba government 49%.

MPC holds a potash deposit near Russell bordering on Saskatchewan, in which reserves of some 165 Mt grading 24.5% K_2O were outlined.

Kilborn Engineering Limited and Matrix Enterprises Ltd. completed an engineering and economic feasibility study in June 1987. The report proposed a 2.0 Mt/y KCl mine. Capital costs are estimated at $540 million in 1987 constant dollars. Direct operating costs were estimated at $26.26/t of product. Project economics were based on a f.o.b. mine price of $73/t. The projected permanent employment was 360, while during the peak construction year 700 would be employed.

The mine would have the advantage of a relatively shallow depth at between 850 and 900 m, about 100 m less than corresponding mines in Saskatchewan. The mining layout provides for especially designed access to each mining panel and isolation pillar barriers as a precaution against the risk of flooding.

MPC is currently trying to find partners with financial backing. Canadian and overseas producing companies and consumer groups were approached. To date, the principal interest was shown by the Minerals & Metals Trading Corp. of India Ltd. (MMTC) which was reported to be prepared to acquire a 20 to 25% equity, together with a guarantee for 500 000 t of production per year which would amount to about a quarter of estimated annual Indian needs by 1995. MMTC would reportedly prefer to offer mining machinery and other countertrade goods for its equity share. Proposed financing would be on a 60:40, debt/equity ratio.

The Manitoba Minister of Mines and Energy said that 1988 will be the year of decision on developing the Russell potash deposit.

NEW BRUNSWICK

The Potash Company of America, Inc. (PCA), majority owned by Rio Algom Limited operates the Penobsquis mine situated 5 km east of Sussex, N.B. The company completed a $30 million project to upgrade the mine and achieve the designed capacity of 380 000 t/y K_2O by late 1987. Most of the objectives were reached but product recovery from ore still requires some improvement. The shaft and some surface installations were designed to a capacity of 545 000 t/y K_2O.

Production at the Penobsquis mine exceeded 500 000 t KCl in 1987. The company has about 340 employees.

The Denison-Potacan Potash Company (DPPC) operated its new Cloverhill mine located 20 km southwest of Sussex, N.B. at about two-thirds of the designed capacity level of 780 000 t/y. Production in 1987 was between 850 000 and 900 000 t KCl.

The company is expected to achieve about 90% operational capacity in 1988. Because of the complexity of the orebody the company intends to continue extracting ore both by drill and blast methods and with continuous mining machines. In early 1987 the company started to return waste salt to the mine as backfill. The backfill system is working well and by year end more than 50% of the surface flotation plant waste was being returned underground. The company plans to return 100% underground by the end of 1989 and waste salt stored on the surface in a tailings pond will be returned underground subsequently. Excess brine is dispatched by pipeline to the Bay of Fundy. Employment at the end of 1987 was 465. The mine was shut down for three weeks for maintenance in July 1987.

DPPC started the installation of a crystallizer unit at a cost of $11 million which will be operational in early 1988.

BP Resources Canada Limited is holding the third commercially viable potash deposit near Sussex, known as the Millstream deposit. BP obtained a mining lease in 1985. Because of the generally depressed potash market conditions, the company deferred a decision on whether to proceed with an exploration shaft, to 1988.

INTERNATIONAL DEVELOPMENT

Argentina - Yacimientos Petroliferos Fiscales (YPF) discovered a potash deposit while drilling for oil in the Province of Mendoza, Department of Malargue along Rio Colorado. The potash occurs in the saline Huitrin Formation, which lies at various depths between 750 and 1 200 m. The deposits are explored under concession by Duval Corporation and Minera TEA, a subsidiary of Texasgulf Inc. Originally it was reported that the potash beds were 1 to 4 m thick consisting of sylvinite ore grading up to 27% K_2O. In August 1986 it was reported that the indications are for 2 billion t of ore grading 20 to 30% KCl (12 to 18% K_2O) in beds 2 to 10 m thick.

Argentina also has potassium bearing brines in the Salar de Hombre Muerto and the Salar del Rinson.

Australia - CRA Limited completed a feasibility study on a 30 000 t/y potassium sulphate project in Dampier, Western Australia. The project can apparently be justified and will be integrated into the Dampier Salt Ltd. plant pending the resolution of some commercial considerations.

Bolivia - A state agency, Complejo Industrial de Recursos Evaporiticos del Salar de Uyuni (Ciresu) was formed to promote the exploitation of brine deposits in the Salar de Uyuni. These brines contain an average of 0.025% Li; 0.54% Mg; 0.62% K; and 9.10% Na. These concentrations are lower than those of the Salar de Atacama in Chile.

Brazil - PETROBRAS Mineracao S.A. (PETROMISA) officially opened the Taquari-Vassouras potash mine in the Sergipe District in March 1985. However as of the end of 1987, all the mining equipment was not yet in place and annual production was substantially below 100 000 t KCl. PETROMISA estimated that it will take three years to bring production up to designed capacity, but this optimism is not shared by all observers.

PETROMISA holds another interesting potash deposit near Fazendinha in the Amazonian basin. The deposit has an area extent of 130 km^2, an average thickness of 2.7 m and lies at a depth of 980 m to 1 140 m. Total reserves are estimated at 560 Mt grading about 27% KCl. In 1984, a $700 000 feasibility contract was awarded to a joint venture consisting of Paulo Abib Engenharia, Mines de Potasse d'Alsace and Patrick Harrison & Company Limited, a Canadian firm. Phase I of this study outlining development options was completed in September 1985 and Phase II comprising a more detailed engineering feasibility was started in 1986 and completed in 1987. PETROMISA stated that if the $1.0 billion, 1.5 Mt/y potash project is approved by the government, production could start in 8 to 10 years.

After varying sharply from year to year in the early 1980s, Brazilian imports appear to have stabilized at about 1.2 to 1.4 Mt/y K_2O, with good prospects for further growth. PETROMISA forecast Brazilian potash consumption to reach 2 150 000 t KCl in 1990.

Chile - AMAX Chemical Corporation jointly with Molibdenos y Metales S.A. (Molymet) were awarded the rights by Corporacion de Fomento de la Produccion (Corfo) to develop the potash-lithium-boric acid deposits of the Salar de Atacama. Sociedad Mineral Salar de Atacama Ltda (MINSAL Ltda) was formed in 1986 with the following equity distribution: AMAX 63.75%, Corfo 25% and Molymet 11.25%.

The Atacama brines contain in average 0.125% Li, 0.91% Mg, 1.87% K, and 6.92% Na. Field tests and feasibility studies will be completed by 1989-90 and if successful may lead to full production by the mid-1990s.

Initially, the target size of the project was 500 000 t/y KCl, 200 000 t/y K_2SO_4, 30 000 t/y of boric acid and an undetermined amount of lithium chemicals. More recently, AMAX stated that annual production could be 550 000 t of KCl equivalents. Initially, there would be a cap on lithium metal production of 2 800 t/y with a provision of annual increases of 7%. The increase in lithium production will be proportionate to potassium sulphate production. Permission to extract lithium, which is in oversupply, is crucial since without it the economic exploitation of the brines would not have been possible. MINSAL estimated that the brine deposit reserves consist of 46.7 Mt KCl and 21.1 Mt sulphate.

Chile currently raised its production of potassium nitrate to 110 000 t/y, which is based mainly on imported muriate of potash.

China - A small potash plant, serving local markets, exists at the eastern part of a dry lake, Lake Qarhan (Chaerhan) in the Qinghai province. Output is about 40 000 t/y KCl of low-grade product grading between 45 and 50% K_2O. Brines are pumped into solar ponds from trenches dug into the dry salt lake surface. Concentrated salts from the solar ponds are subject to rough flotation producing the low-grade product. Currently, construction is well advanced on additional solar ponds that will provide the raw material for a nearby plant of 200 000 t/y KCl capacity to be completed by 1989. As of the end of 1987, construction was ahead of schedule. A 13 km railway spur and a 60 km fresh water conduit were completed. Capital costs are estimated at 400 million yuan (US$108 million).

A western harvesting machine for the solar potash pond was ordered. The Chinese are also interested in contracting a feasibility study on a 800 000 t/y KCl plant for the west end of Lake Qarhan to be based on western technology that would yield a high-grade product for markets outside western China. Such a plant would require $500 to $600 million in investment and is not likely to be completed earlier than in mid- to late 1990s.

Chinese annual consumption of potash is variously estimated at between 600 000 t and 1.0 Mt K_2O. Imports declined to very low levels in 1985. There was a substantial improvement in 1986 and in 1987 imports and consumption returned to normal levels. By 1990, consumption may reach 900 000 t to 1.0 Mt K_2O.

Congo (People's Republic) - Entreprise minière et chimique (EMS) signed a joint venture agreement with the Congolese government to establish the feasibility of mining potash again at Holle, near Pointe Noire. A feasibility study was in progress in 1987. Mining was carried out there from 1969 to 1977 when the mine was flooded.

France - Production in 1987 was approximately 50 000 t K_2O less than in 1986, principally in response to lower domestic consumption, higher imports and the closure of the Theodore mine in March 1986. Mines de Potasse d'Alsace put into operation a new flotation plant at the Amelie mine, increasing recovery and thus partially compensating for the Theodore closure. A second mine will be closed in four to five years resulting in a further decrease of French capacity by up to 400 000 t/y. In October 1986 the French Ministry of Environment announced a F Fr 350 million program to appreciably reduce the discharge of waste salt into the Rhine. Under the plan, a total reduction of 60 kg per second (1.9 Mt/y) would be implemented over a two-year period. The first phase, equivalent to a reduction of 20 kg per second, was implemented in 1987. Eventually all of the waste salt will be stocked on the surface and only a portion will be used for road de-icing.

German Democratic Republic (GDR) - Production from ten mines in the GDR for the past few years has been more or less steady. In 1986, GDR produced 3 485 000 t K_2O and in 1987 production was estimated at 3 500 000 t K_2O. Production in 1988 is expected to remain at the same level.

GDR, through its marketing agency Kali-Bergbau, currently exports approximately 2.90 Mt K_2O of which about 56% is to market-economy countries and China, and 44% to COMECON countries including Cuba.

Germany, Federal Republic of (FRG) - Kali und Salz AG (K&S) is the sole producer of potash in FRG. Production in 1987 was estimated at 2.17 Mt K_2O, similar to the low level of 1986. FRG is the major exporter of potash in the EEC, but 65% of its exports are intra-western Europe.

K&S rationalized its potash capacity in 1987 reducing it to 2.7 Mt K_2O. The small Siegfried-Giesen mine was closed, capacity was reduced by half at the Bergmannssegen-Hugo mine and by a smaller amount at the Salzdetfurth mine. The combined capacity at the four mines in Lower Saxony is now 1.1 Mt/y K_2O and that at the three Hessen mines is 1.6 Mt/y.

India - India has no domestic production of potash and imports it mainly from Canada, GDR, Jordan and FRG. Until recently, about one-third of its 800 000 to 1.0 Mt K_2O annual import requirements came from Canada. In 1987 Canadian imports accounted for less than one-quarter, and the Jordanian share rose considerably. The government-owned Minerals & Metals Trading Corp. of India Ltd. (MMTC) gives priority to countertrade business or to potash that is provided through an EEC aid program. Imports in 1987 suffered as a result of severe drought conditions but were expected to improve starting in late 1987. MMTC expressed some interest in acquiring equity in a Canadian potash mine. In particular MMTC is examining a proposal to take a 20 to 30% equity in a proposed new mine in Manitoba.

Israel - The Dead Sea Works Ltd. (DSW) potash plant at Sdom has a capacity of 2.1 Mt/y KCl. An additional 200 000 t/y capacity will be added over the next two to three years. The expansion work involves the debottlenecking of the hot crystallization plant, modifications to the cold crystallization plant and to the solar ponds by switching a salt pond to carnallite precipitation, which became technically feasible because of the rising salinity of the Dead Sea. Further capacity additions are possible in the future if new ponds are added. There is a limitation, however, on the available land area for pond construction and DSW is currently conducting tests to determine if the newly exposed seabed area is suitable for this purpose. The 250 000 t/y KCl flotation plant closed since April 1985 is held on maintenance with a view to possible reactivation.

A transportation system, including an 18 km conveyor belt from Sdom to a new rail terminal at Tsefa which eliminated costly truck haulage was commissioned in March 1987 (the elevation difference is 800 m). Consideration is also being given to a rail link to the port of Eilat in the more distant future. DSW reported technical difficulties with its granulation plant in the fall of 1987.

Haifa Chemicals Ltd. expanded its potassium nitrate capacity from 200 000 t/y to 250 000 t/y KNO_3.

Italy - Societa Italiana Sali Alcalini SpA (Italkali), a government controlled company, produces potassium sulphates from two Sicilian mine groups which together have reserves of more than 150 Mt of kainitic ores (10 to 12% K_2O). Realmonte produces about 400 000 t/y of kainite ore and Pasquasia about 0.9 Mt. Two refineries at Casteltermini and Pasquasia had an originally designed capacity of 170 000 t/y and 230 000 t/y of potassium sulphate, but were never capable of producing at that level. Modernization of the Pasquasia mine-mill complex over the past two years is almost complete and by early 1988 Pasquasia could operate at 90% of full capacity. It will take up to 1990 to bring the Casteltermini plant (also known as Campofranco) to design capacity.

Jordan - The Arab Potash Co. Ltd. (APC) made steady progress toward full capacity utilization of its Dead Sea potash plant at Ghor-al-Safi. Production in 1987 was estimated at over 700 000 t K_2O compared to 662 000 t in 1986. The Arab Potash Co. Ltd. (APC) selected the Finnish company, Yleinen Insinööritoimisto (YIT), to carry out an US$11 million expansion and modification of the potash refinery. The project will be completed towards the end of 1988 and will raise the productive capacity to 840 000 t/y.

APC will also undertake dredging work to deepen the existing Dead Sea brine intake channel and to remove salt reefs in the principal solar evaporation pond. During the past five years the Dead Sea level has been falling faster than originally anticipated and the work on the intake channel must be completed by 1989. APC will also be given a grant of US$1.5 million from the U.S. Agency for International Development to experiment with a cold leach and crystallization process which could save energy.

Spain - The Spanish potash industry produced approximately 745 000 t K_2O in 1987 compared to 702 000 t in 1986.

Potasas de Subiza, owned 50% by Instituto Nacional de Industria (INI) and 50% by the local government, El Gobierno Foral de Navarra completed the first full year of production at a better than originally anticipated production level. Ore reserves are limited but will allow for the operation of the Subiza mine to the 1993-95 period. Thereafter, potash mining in Spain will be concentrated in the Catalonia District where capacity at the Suria mine will be expanded. There is also a possibility of opening a new mine between Suria and Llobregat in the more distant future. There is some uncertainty as to whether the Cordona mine can remain in operation in the 1990s, unless major exploration efforts are successful.

During 1987, Kuwaiti interests increased their control of Explosivos Rio Tinto S.A. to about 25%. The company controls the Cordona and the Llobregat mines.

Thailand - Thailand has two potash bearing saline basins, the Khorat (33 000 km^2) and the Sakhon-Nakhon basins (17 000 km^2). The Department of Mineral Resources (DMR) started a pilot project in 1982 to demonstrate the feasibility of carnallite exploitation near Chaiyaphum in the Khorat basin. An inclined access drift was sunk but had to be abandoned because of high water inflow in 1983.

In 1984 two potash concessions were awarded: one to Thai Potash Co. Ltd. (CRA Limited - Duval Corporation - Siam Cement Co.) on 3 500 km^2 and the other to Thai Agrico Potash Co. Ltd. (Agrico Chemical Co. - Thai Central Chemical) on 2 333 km^2. Each company was committed to spend on exploration a total of US$3 million over a five-year period. Agrico was reported to be ready to relinquish the concession. In 1987 BHP-Utah International Inc. was negotiating for a 9 000 km^2 concession in the Sakhon-Nakhon basin. The Thai deposits present a geological challenge since the disposition of secondary sylvinitic ore is discontinuous in predominantly carnallitic potash formations.

Tunisia - As reported in 1986, an initial feasibility study was completed on the possibility of extracting potassium and other salts from the Zarsis brines by French companies. Société de Développement des Industries Chimiques du Sud (S.D.I.C.S.) was reported to be looking for companies interested in pursuing further research and development. Apparently a 120 000 t/y K_2O potassium sulphate plant would be a part of the development plan.

United Kingdom - Cleveland Potash Ltd. had an exceptionally good year and produced an estimated 423 000 t K_2O in 1987. The company completed the installation of a pilot facility to recover potash from brines in 1986. The unit is working well and above originally designed capacity; it is based on a refrigeration technique whereby potash crystals are separated from the frozen brine.

The company is steadily gaining experience in mining in difficult ground conditions and is expected to further increase output in 1988. Cleveland Potash Ltd. resigned from Kali Export, as of May 1, 1987.

United States - Production in 1987 was estimated at just about 1 200 000 t K_2O, about 30 000 t above the 1986 level. There was an improvement in the second half of the year when mines operated at an annualized rate of 1 350 000 t. Production is expected to show a further improvement in 1988 but will continue to decline thereafter.

Total U.S. nominal potash capacity currently at 1 400 000 t/y K_2O is likely to decline to about 840 000 t by 1992 as a result of the closures of the AMAX and Lundberg mines in New Mexico, with a small compensation by the re-activation of the Great Salt Lake plant in Utah. A positive supply-demand picture may induce Kalium Chemicals to start solution mining in Michigan by 1994 or shortly thereafter.

Great Salt Lake Minerals & Chemicals Corporation (GSL) ceased operations at its Utah plant in 1984 when Great Salt Lake rose to abnormally high levels and evaporation ponds were flooded. The company started pumping operations in April 1987 which will last three to four years. If pumping is successful, initial production may start-up in 1989 but it would take a further three years to reach full capacity of 218 000 t/y K_2SO_4.

AMAX Chemical Corporation reopened its Carlsbad, New Mexico mine on March 30, 1986. The mine was closed since October 5, 1985. The company is now concentrating on mining the remaining reserves in the higher grade No. 1 zone and is effectively operating at a capacity of approximately 360 000 t/y K_2O. High grade reserves, currently recovered through retreat mining will be exhausted by the beginning of 1989.

New Mexico Potash Corp. operates the former Kerr-McGee mine at Hobbs, N.M. The plant capacity was rationalized to just slightly above half the former rate of 300 000 t/y. The company produces essentially high grade chemical potash but is selling part of its output in fertilizer markets.

Texasgulf Inc. operates a solution and solar evaporation mine in Moab, Utah. Production of potash was expected to end in 1988 but because of good markets for the by-product common salt, it was decided to keep potash production on an indefinite basis at about half the original installed capacity of 110 000 t/y. The company is also examining the possibility of expanding solution mining in the future to areas outside the flooded conventional mine from which the potash now originates.

Lundberg Industries Inc. reopened the former PCA mine at Carlsbad, New Mexico, in March 1986. The company encountered technical economic and other difficulties. The company was engaged in an ownership litigation with the former mine owner, Ideal Basic Industries, Inc. At mid-year, the company filed for bankruptcy under Chapter 11. On December 21, 1987 a Grand Jury issued an indictment covering 29 counts against certain Lundberg defendants.

In September 1987 the mine was placed in the hands of a trustee. The mine was closed from the beginning of the year to February 10 and from mid-July to mid-August. The mine is operated on a 10 days on, 4 days off schedule, thus perhaps at a rate which is less than optimum. By year-end, the trustee reported good results with monthly production at about 45 000 t. The workforce is between 365 and 370. Ore is currently extracted from the high grade No. 1 bed and reserves on this horizon are not expected to last for much beyond 1991-92. The life expectancy of this mine however could be prolonged if it was economically and technically feasible to extract some ore from a lower grade No. 3 bed and blend it with the higher grade material.

Kalium Chemicals completed the construction of test facilities at their Hersey site in Michigan in August 1985 under a $5 million program which tested the feasibility of solution mining of potash beds that occur at a depth of 7 500 to 8 000 ft. in the Michigan salt basin. Technical tests were carried out during 1986, and the plant was temporarily closed. Further testing is planned in 1988. Favourable results could lead to the construction of a 425 000 t/y K_2O plant by 1994 at the earliest.

Western Ag-Minerals Co. produces potassium sulphates at its Carlsbad, New Mexico plant. The company operated somewhat below optimum capacity in 1987 and closed for about two weeks in August. Markets for its sulphate products are expected to improve from late 1987 onwards. Western Ag is 35% owned by a Canadian company, Rayrock Yellowknife Resources Inc.

International Minerals & Chemical Corporation (IMC) mines sylvinite and mixed sylvinite and langbenite ores at their Carlsbad mine thus producing chloride and sulphate products. The company operated throughout 1987 at near full capacity levels.

U.S.S.R. - The U.S.S.R. is the world's leading producer of potash and the second largest exporter after Canada. In 1986 the U.S.S.R. exported 3 014 900 t of which 29% was to market-economy countries and China and 71% to COMECON countries, including Cuba, North Korea and Vietnam. There was a 7.1% decline in exports between 1986 and 1985 due to production deficiencies. A further small drop in exports was expected in 1987. The Berezniki 3 mine in the Urals, one of the most modern mines in the U.S.S.R., was flooded in March 1986. This mine had a capacity of 1 150 000 t/y K_2O. The loss of this mine will probably be permanent.

After delays of several years, a new mine, Berezniki 4 started production in late 1987. The mine was previously reported to have been flooded or to have experienced serious water problems. Phase I capacity will be approximately 625 000 t/y K_2O. A 2 Mt/y KCl crystallization plant built by Lurgi GmbH is expected to be completed in mid-1988. This would allow the start-up of Phase II by 1989-90. Berezniki 4 was designed to be the largest of the Soviet potash mines, reaching a capacity of 1.6 Mt/y K_2O by 1995, which is higher than the 1.25 Mt/y K_2O attributed to the two crystallization units. The Novosolikamsk mine currently operates at a capacity of between 800 000 t and 900 000 t and is still under expansion to approximately 1.2 Mt/y K_2O in the early 1990s. Research facilities at the Karlyuk potash brines operation are already in place and small quantities of potash were produced. It is surmised that a larger commercial plant will not be completed and effectively operational before 1991.

The Soviet Union is putting more emphasis on agriculture and domestic fertilizer consumption; in the potash sector the rate of growth in consumption between 1987 and 1995-96 may exceed the growth in production.

RESEARCH AND DEVELOPMENT

The Canada Centre for Mineral and Energy Technology (CANMET) with the close cooperation of the potash industry is involved in a number of R&D potash projects. CANMET involvement began in 1983 under the START program (Short Term Aid to Industry for Research and Technology).

Projects completed under START are as follows:

- Environmental changes associated with potash tailings stored on surface.
- Guide to government regulations for potash mining and processing concerning the environment.
- Alternatives to present potash mining in Canada.
- Assessment of possible problems in regional mine stability with future mining of Saskatchewan potash.
- Creep cell evaluation and laboratory testing of large evaporite samples.
- Numerical modelling package to design underground openings in potash.
- Determination of engineering properties of waste salt for backfilling underground potash mines.
- Dust measuring techniques and dust levels in potash mines.
- Absolute convergence measurements in potash mine openings.
- A field test program to evaluate the use of waste salt backfill in Saskatchewan potash mines.

Ongoing projects are:

Saskatchewan

- Excavation behaviour at Cominco potash mine.
- Application of SPASID subsidence model to Saskatchewan conditions.
- Identification of input parameters for numerical modelling of potash strata at IMC.

New Brunswick

- Rock Mechanics Program at the Potash Company of America Inc.'s mine at Sussex.
- Backfill mining trial at Denison-Potacan Potash Company.

Federal-provincial-industry potash R&D is also being conducted under the current five-year Mineral Development Agreements (MDA) with the provinces of New Brunswick and Saskatchewan. The following studies were completed or are in progress:

- Electrostatic separation of potash ore. (completed)
- Dense medium Tri-flow separation of potash ore. (Phase I - laboratory completed; Phase II - pilot - under way)
- High intensity, high gradient magnetic separation of insolubles in clays from potash salts. (pilot studies - under way)
- Use of backfill in New Brunswick potash mines. (under way)
- Regional subsidence related to potash mining. (completed)
- Research on microseismic technology. (completion in February 1988)
- Offshore product quality. (Phase I completed; Phase II under way)

New Projects

- Salt anomaly prediction. (started October 1987)
- Long-term management options for tailings. (started December 1987)

For further information on potash R&D contacts at CANMET (tel. 613-995-4029) are: D.G. Feasby and Dr. G. Herget.

PRICES

Typical contract prices for Canadian potash (standard grade KCl) moving out of Vancouver were US$58-60/t at the beginning of the year; prices moved to the low 60's in March. Starting in April price recovery acquired momentum, with a rise to US$68-72/t by August and a further rise to US$76-82/t levels towards the end of the year. Indicative prices for the first quarter of 1988 are close to the US$80/t range. A further significant rise is expected.

Prices for delivery in the United States were listed at US$50-52/s.t. f.o.b. mine at the beginning of the year, with considerable discounts from this level taking place. By mid-year prices moved to a firmer level of US$56-58/s.t. Companies were forced to raise prices following the August 21 U.S. Department of Commerce (DOC) preliminary determination of dumping against Canadian exporters. A leading company raised prices across the board on all grades of potash by US$35/s.t. and all other exporters raised their quotations to a similar level. Standard grade was quoted at about US$82/s.t. in October until mid-December. In mid-November, companies announced a further increase of US$7/s.t. effective December 14, 1987 (standard grade US$89/s.t.) Prices in the United States were reduced across the board by about US$17/s.t. following the suspension settlement on the dumping charges signed on January 8, 1988.

OUTLOOK

There is a general perception in the potash industry that 1986-87 was the worst period and that markets are improving and will continue to improve; first slowly in 1988 and 1989 and then at an accelerated pace in the early 1990s.

Agronomists expect that grain planting acreage reductions in the United States have now reached optimum levels and that demand in 1988 will be about the same as in 1987. Canadian sales to the United States in 1988 will remain at a level of approximately 4.1 Mt. Canadian sales abroad which reached a record level of over 3.0 Mt in 1987 will remain stable in 1988 with a possibility of a marginal decline in the first half followed by a strong fall season.

Canadian capacity utilization in 1988 will be between 67 to 68%, about the same as in 1967; capacity utilization of 80% which is still below optimum will not be reached before 1990.

The U.S.S.R. is likely to drop potash exports to western economies and COMECON countries; the main burden of restricted supply due to mine floodings fell on its own domestic consumption. However after 1987, domestic needs are bound to take precedence over high export levels so exports are expected to continue to decline slowly over the next few years.

It is reasonable to expect a steady improvement in demand from most Latin American as well as Asian countries, particularly China, so that Canadian offshore exports in the early 1990s will reach equality with North American sales.

However, it will take four to six years, depending on rapidly changing circumstances, before new additions to capacity are required anywhere in the world; as already ongoing, committed expansions will add another 1.1 Mt/y by 1990. It is assumed that world demand for potash will resume an upward growth of between 2.0 and 2.4%/y.

The International Fertilizer Industry Association Ltd. (IFA) recently revised its world demand for potash forecast downward. In 1985 IFA forecast the 1995 world demand to be 36.8 Mt K_2O. IFA's 1987 forecast for 1995 is only 31.4 Mt. The revision was entirely on account of lower fertilizer use in Developed Market Economies and eastern Europe. A more plausible consumption forecast would be between 32.5 and 33.0 Mt K_2O for fertilizer use. It would imply a demand for all purposes of between 34.0 and 34.5 Mt. With world nominal capacity at only 36.6 Mt by 1995, the supply-demand balance may be very tight indeed. The forecast implies a capacity utilization level of 95%, which is not sustainable in the long range.

It is therefore quite evident that several Canadian companies will soon start to examine ways and means of expanding production targeted for the mid-1990s. This may also include new mine construction.

TABLE 1. CANADA, POTASH PRODUCTION, SHIPMENTS AND TRADE, 1985-87

	1985		1986		1987P	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Production, potassium chloride						
Gross weight	10 959 900	..	10 938 161	..	..	..
K_2O equivalent	6 694 507	..	6 677 983	..	..	..
Shipments						
K_2O equivalent	6 661 077	629 547	6 752 709	584 304	7 464 930	705 826
Imports, fertilizer potash						
Potassium chloride						
United States	707	622	391	458	861	462
Potassium sulphate						
United States	27 655	2 831	25 668	4 822	11 641	2 492
France	3 001	846	-	-	-	-
Italy	182	48	338	94	132	36
West Germany	-	-	-	-	40	11
Total	30 837	3 725	26 006	4 917	11 813	2 539
Potassic fertilizer, n.e.s.						
United States	33 687	4 794	23 991	3 947	51 503	6 789
Potash chemicals						
Potassium carbonate	1 170	738	1 359	1 164	1 545	1 049
Potassium hydroxide	2 620	1 777	4 388	2 240	4 091	2 302
Potassium nitrates	4 505	2 237	4 037	2 097	4 523	2 243
Potassium phosphates	2 074	2 456	3 730	3 885	3 714	4 097
Potassium silicates	4 744	3 945	698	585	893	671
Total potassium chemicals	15 113	11 153	14 212	9 971	14 766	6 265
Exports, fertilizer potash						
Potassium chloride, muriate						
United States	6 449 767	525 651	5 876 482	425 620	6 028 110	513 415
People's Republic of China	194 351	24 285	310 842	27 224	794 458	68 486
Japan	625 882	79 828	564 439	56 240	738 240	68 308
Brazil	425 011	53 123	776 600	79 797	654 001	63 050
South Korea	331 681	42 252	394 630	39 361	532 336	47 488
Indonesia	179 050	23 009	224 386	23 489	334 905	30 967
Malaysia	153 160	18 465	193 458	19 615	288 958	26 204
Australia	166 130	21 485	176 838	17 645	237 198	20 387
India	528 403	67 291	469 227	47 254	208 019	19 448
Netherlands	-	-	41 660	4 155	178 839	17 839
Singapore	136 401	17 828	17 893	1 863	135 616	12 467
France	102 236	12 577	149 337	14 896	111 624	9 644
Denmark	27 728	2 594	85 943	8 083	102 308	9 393
Bangladesh	94 846	10 778	15 750	1 736	94 347	8 827
Taiwan	64 767	8 472	42 151	4 424	71 201	5 143
New Zealand	20 089	2 590	36 537	3 734	67 083	5 777
Norway	6 080	581	10 528	993	61 133	5 541
Colombia	12 618	1 432	13 713	1 013	49 601	4 902
Philippines	21 642	2 811	18 000	1 872	42 976	3 687
Ireland	17 229	2 270	14 108	1 648	33 290	2 874
Belgium-Luxembourg	-	-	77 099	7 838	33 148	2 852
United Kingdom	33 212	4 004	31 364	3 357	25 252	2 500
Italy	29 213	3 126	41 269	4 045	25 162	2 177
Mexico	63 025	6 673	49 209	5 078	22 000	1 896
South Africa	41 501	5 414	24 634	2 505	14 750	1 276
Guatemala	4 100	456	27 842	2 906	13 247	1 465
Chile	36 251	4 455	53 956	5 465	13 200	1 132
Venezuela	-	-	70 006	7 333	-	-
Hong Kong	-	-	34 945	3 614	-	-
Other countries	38 087	4 899	51 190	5 261	71 338	7 029
Total	9 802 460	946 349	9 894 036	828 074	10 983 067	965 175

Sources: Statistics Canada; Energy, Mines and Resources, Canada.
P Preliminary; - Nil; .. Not available; n.e.s. Not elsewhere specified.

TABLE 2. CANADA, POTASH PRODUCTION AND SALES BY GRADE[1] AND DESTINATION, 1985 AND 1986

	1986						1985
	Standard[2]	Coarse	Granular	Soluble	Chemical[3]	Total	Total
	(tonnes K_2O equivalent)						
Production	1 825 980	1 938 641	2 229 714	647 397	55 836	6 697 568	6 636 658
Sales							
Canada	18 252	104 045	197 247	10 504	..	327 379	433 830
United States	368 813	1 805 939	1 501 801	414 775	..	3 880 719	4 160 614
Offshore							
Argentina	1 217	1 826	-	-	..	3 043	-
Australia	2 779	21 888	77 797	1 974	..	126 897	95 654
Bangladesh	19 052	-	-	-	..	19 052	28 802
Belgium	6 968	-	-	-	..	6 968	-
Brazil	105 164	138 535	254 911	3 130	..	501 741	253 154
Chile	26 171	-	-	-	..	26 171	24 232
China	283 965	-	-	-	..	283 965	105 682
Colombia	8 361	-	7 634	-	..	15 995	-
Costa Rica	9 488	3 549	-	-	..	13 037	12 836
Denmark	51 830	-	-	-	..	51 830	20 065
Dom. Rep.	-	-	2 579	-	..	2 579	2 683
Ecuador	-	-	3 160	-	..	3 160	-
France	12 195	-	-	-	..	12 195	46 881
Guatemala	3 993	-	9 781	-	..	13 775	3 090
Honduras	-	-	-	-	..	-	(34 733)
India	298 820	-	-	8 633	..	307 453	312 141
Indonesia	166 946	-	-	-	..	166 946	104 668
Ireland	-	-	7 036	-	..	7 036	6 851
Italy	16 055	-	-	16 390	..	32 445	18 364
Jamaica	-	5 790	2 899	-	..	8 689	3 464
Japan	148 950	54 188	30 506	119 344	..	352 987	359 654
Korea, South	198 813	-	-	25 318	..	224 131	186 349
Malaysia	130 865	-	-	-	..	130 865	127 505
Martinique	-	-	-	-	..	-	872
Mexico	29 994	-	-	-	..	29 994	38 233
New Zealand	20 613	1 658	-	-	..	22 272	24 429
Panama	-	-	-	-	..	-	885
Pakistan	23	-	-	-	..	23	-
Peru	7 199	-	-	-	..	7 199	1 281
Philippines	10 346	-	-	-	..	10 346	22 415
Puerto Rico	-	2 293	-	-	..	2 293	-
South Africa	3 017	1 596	10 338	-	..	14 952	25 228
Sri Lanka	12 778	-	-	-	..	12 778	43 732
Switzerland	112 627	-	22 589	-	..	135 216	50 429
Taiwan	43 590	-	-	-	..	43 590	39 367
United Kingdom	400	-	2 262	-	..	2 662	455
Venezuela	21 187	-	21 366	-	..	42 555	3 222
Offshore total	1 753 407	231 323	452 860	174 789	..	2 612 379	1 927 892
Total sales	2 138 778	2 141 307	2 151 907	599 093	..	7 031 086	6 522 337

Source: Potash and Phosphate Institute.

[1] Common specifications are: standard -28 to +65 mesh, special standard -35 to +200 mesh, coarse -8 to +28 mesh, granular -6 to +20 mesh, each grading a minimum of 60% K_2O equivalent, soluble and chemical grade a minimum of 62% K_2O equivalent. [2] Standard includes Special Standard, sales of which were 154 993 t K_2O equivalent in 1985, and 213 649 t in 1986. [3] Chemical sales are included in standard grade sales and totalled 54 717 t in 1986.

- Nil; .. Not available.

TABLE 3. CANADA, POTASH PRODUCTION AND TRADE, FERTILIZER YEARS-ENDED JUNE 30, 1966, 1971, AND 1976-87

	Production[2]	Imports[1,2]	Exports[2]
	(tonnes K_2O equivalent)		
1966	1 748 910	31 318	1 520 599
1971	3 104 782	26 317	3 011 113
1976	4 833 296	16 445	4 314 150
1977	4 803 015	24 289	4 175 473
1978	6 206 542	26 095	5 828 548
1979	6 386 617	21 819	6 256 216
1980	7 062 996	20 620	6 432 124
1981	7 336 973	35 135	6 933 162
1982	6 042 623	25 437	5 400 662
1983	5 378 842	21 846	4 864 219
1984	7 155 599	17 934	6 730 733
1985	7 283 509	17 396	6 784 178
1986	6 519 777	12 837	6 479 678
1987	7 031 586	12 122	7 100 135

Source: Potash and Phosphate Institute, Canadian Fertilizer Institute.

[1] Includes potassium chloride, potassium sulphate, except that contained in mixed fertilizers. [2] Change of data source. Prior to 1978 figures were obtained from Statistics Canada.

TABLE 4. CANADA, POTASH PRODUCTION AND SALES IN 1986 AND BY QUARTERS, 1987

	Total (1986)	1987			
		1st quarter	2nd quarter	3rd quarter	4th quarter
	(000 tonnes K_2O)				
Production	6 697.6	1 854.3	2 033.9	1 489.0	1 889.5
Sales					
North America	4 418.7	1 406.3	1 423.9	943.9	949.6
Offshore	2 612.4	791.0	812.1	700.5	809.9
Total	7 031.1	2 197.3	2 236.0	1 644.4	1 759.5
Ending Inventory					
Mine site	610.7	400.2	612.6	454.6	380.2
Offsite	925.9	879.2	530.2	505.1	755.0
Total	1 536.6	1 279.4	1 142.8	959.7	1 135.2

Source: Potash and Phosphate Institute.

TABLE 5. CANADA'S PRODUCTION, SHIPMENTS AND SALES OF POTASH, 1970-86 (RECONCILIATION TABLE)

	Production (1)	Production (2)	Shipments (3)	Sales (4)	Exports and Domestic Sales (5)	Differences		
						(1) - (3)	(1) - (4)	(4) - (5)
			(000 tonnes K_2O)					
1970	3 173.3		3 102.8	3 051.5	3 203.4	+70.5	+121.8	-151.9
1971	3 572.9		3 628.4	3 605.2	3 646.8	-55.5	-32.3	-41.6
1972	3 927.7		3 494.6	3 709.4	3 706.7	+433.1	+218.3	+2.7
1973	4 262.0		4 453.8	4 787.4	4 348.9	-191.8	-525.4	+438.5
1974	5 480.5		5 776.1	5 778.6	5 784.0	-295.6	-298.1	-5.4
1975	5 435.7		4 673.4	4 638.2	4 645.3	+762.3	+797.5	-7.1
1976	4 995.9		5 215.4	5 173.1	5 284.2	-219.5	-177.2	-111.1
1977	6 088.6		5 764.2	5 678.9	5 864.8	+324.4	+409.7	-185.9
1978	6 109.6	6 123.5	6 344.0	6 463.2	6 096.1	-234.4	-353.6	+367.1
1979	6 704.7	6 714.7	7 074.4	7 155.4	6 870.8	-369.7	-450.7	+284.6
1980	7 302.9	7 300.2	7 201.2	7 110.7	6 815.6	+101.7	+192.2	+295.1
1981	7 146.6	7 174.6	6 548.7	6 336.5	6 472.9	+597.9	+810.1	-136.4
1982	4 912.0	5 207.9	5 308.5	5 051.5	4 677.9	-396.5	-139.5	+373.6
1983	5 929.5	5 928.9	6 228.3	6 556.7	5 852.8	-298.8	-627.2	+703.9
1984	7 794.0	7 748.7	7 527.0	7 068.1	7 447.0	+267.0	+725.9	-378.9
1985	6 694.5	6 636.7	6 661.1	6 522.3	6 413.4	+33.4	+172.2	+108.9
1986	6 678.0	6 697.7	6 752.7	7 031.1	6 362.8	-74.1	-353.1	+668.8
Cumulative								
1970-86	96 208.4		95 754.6	95 717.8	93 493.4	+453.8	+490.6	+2 224.4

(1) Production as reported to Statistics Canada/EMR.
(2) Production as reported by the Potash and Phosphate Institute (PPI).
(3) Shipment is product that left the mine site (Statistics Canada).
(4) Sales are company sales directly from the mine or from regional warehouse facilities including some in the United States (as reported by PPI).
(5) Exports as reported by Statistics Canada plus domestic Canadian sales as reported by PPI.

TABLE 6. CANADA, POTASH SALES BY PRODUCT AND AREA, 1985 AND 1986

		Agricultural					Industrial			Total Sales
		Standard	Coarse	Granular	Soluble	Total	Standard	Soluble	Total	
		(tonnes K_2O equivalent)								
Alberta	1985	207	1 716	22 708	2 964	27 594	5 419	786	6 204	33 798
	1986	48	1 458	23 438	2 136	27 081	2 307	412	2 719	29 800
British Columbia	1985	(32)	681	5 637	62	6 349	-	-	-	6 349
	1986	-	358	11 859	81	12 298	-	-	-	12 298
Manitoba	1985	-	4 543	14 752	1 630	20 925	-	-	-	20 925
	1986	15	4 593	13 731	1 647	19 987	-	12	12	19 999
New Brunswick	1985	-	-	5 766	-	5 766	-	-	-	5 766
	1986	-	4 257	11 412	59	15 728	-	-	-	15 728
Nova Scotia	1985	-	(111)	4 964	-	4 854	-	-	-	4 854
	1986	15	289	3 352	-	3 657	-	-	-	3 657
Ontario	1985	177	149 840	61 247	2 447	213 711	3 797	3 945	7 742	221 453
	1986	217	74 639	43 969	2 820	121 646	7 627	1 012	8 639	130 285
Prince Edward Island	1985	24	349	7 913	-	8 281	-	-	-	8 281
	1986	-	855	9 546	-	10 402	-	-	-	10 402
Quebec	1985	16 627	25 464	67 090	3 350	112 532	176	-	176	112 708
	1986	1 667	16 003	68 152	182	86 004	434	-	434	86 438
Saskatchewan	1985	-	887	8 636	89	9 612	6 895	2 400	9 294	18 906
	1986	286	1 591	11 786	117	13 780	3 485	1 051	4 536	18 316
Newfoundland	1985	373	-	-	-	373	417	-	417	790
	1986	245	-	-	-	245	212	-	212	457
Totals	1985	17 377	183 365	198 713	10 542	409 996	16 703	7 131	23 833	433 830
	1986	2 493	104 045	197 247	7 043	310 828	14 065	2 487	16 552	327 380

Source: Potash and Phosphate Institute.
- Nil. (Brackets) indicate negative quantities.

TABLE 7. CANADA, POTASH INVENTORY, PRODUCTION, DOMESTIC SALES AND EXPORT SALES, 1986

					Export Sales			
			Domestic Sales		United States			
	Beginning Inventory	Production	Agri-cultural	Non-agri-cultural	Agri-cultural	Non-agri-cultural	Offshore	Total Sales
					(000 tonnes K_2O)			
January	1 565.9	527.8	50.8	1.7	570.6	19.6	130.7	773.4
February	1 597.4	557.6	36.6	2.0	242.6	15.9	252.5	549.6
March	1 581.4	644.4	23.2	1.6	287.9	13.7	195.2	521.6
April	1 765.3	671.7	42.2	1.0	644.5	14.5	254.6	956.8
May	1 491.1	590.0	51.0	1.7	417.5	21.9	274.8	766.9
June	1 356.3	562.8	15.8	1.6	144.0	14.8	182.5	358.7
Sub-total		3 554.3	219.6	9.6	2 307.1	100.4	1 290.3	3 927.0
July	1 532.8	272.9	8.4	0.3	91.6	8.9	246.9	356.1
August	1 442.5	466.2	12.1	1.3	259.5	14.4	148.7	436.0
September	1 510.9	567.5	28.3	1.5	402.5	18.6	248.0	698.9
October	1 326.3	640.1	16.8	1.3	191.9	17.9	199.3	427.2
November	1 529.8	658.1	4.3	0.9	224.8	23.0	180.5	433.5
December[1]	1 759.6	537.3	16.4	1.5	403.2	27.5	295.8	744.4
Sub-total		3 142.1	86.3	6.8	1 573.5	110.3	1 319.2	3 096.1
Total 1986		6 697.7	305.9	16.4	3 880.6	210.7	2 609.5	7 023.1
1985		6 636.4	410.2	23.7	4 027.2	188.0	1 927.8	6 577.7
% change 1986/85		+0.9	-25.4	-30.8	-3.6	+12.1	+35.4	+6.8

Source: Potash and Phosphate Institute of North America.

[1] Inventory at the end of December 1986 was 1 536 610 t. Inventory changes are based on shipments and do not exactly match the sales and production records.

TABLE 8. CANADA, POTASH INVENTORY, PRODUCTION, DOMESTIC SALES AND EXPORT SALES, 1987

					Export Sales			
			Domestic Sales		United States			
	Beginning Inventory	Production	Agri-cultural	Non-agri-cultural	Agri-cultural	Non-agri-cultural	Offshore	Total Sales
					(000 tonnes K_2O)			
January	1 536.6	529.4	119.3	1.3	463.3	15.1	201.3	800.3
February	1 299.4	615.1	33.1	1.6	321.2	17.7	237.9	611.5
March	1 342.1	709.8	30.2	1.2	378.8	23.2	351.8	785.2
April	1 279.3	688.4	51.0	1.5	495.7	18.5	290.3	857.0
May	1 106.1	709.4	49.6	1.4	304.6	16.3	264.0	635.9
June	1 188.2	636.1	28.6	2.3	429.5	24.9	257.8	743.1
Sub-total		3 888.2	311.8	9.3	2 393.1	115.7	1 603.1	4 433.0
July	1 142.8	316.9	16.6	1.9	137.4	17.2	260.2	433.3
August	915.5	531.7	21.6	1.2	315.8	15.4	230.0	584.0
September	933.7	640.4	50.2	1.5	346.5	18.7	210.3	627.2
October	959.7	701.8	26.9	1.9	210.6	20.0	312.3	571.7
November	1 088.2	641.0	24.0	3.2	208.0	17.5	208.5	461.2
December[1]	1 265.0	546.7	26.8	2.7	383.1	24.9	289.1	726.6
Sub-total		3 378.5	166.1	12.4	1 601.4	113.7	1 510.4	3 404.0
Total 1987		7 266.7	477.9	21.7	3 994.5	229.4	3 113.5	7 837.0
1986		6 697.7	305.9	16.4	3 880.6	210.7	2 609.5	7 023.1
% change 1987/86		+8.5	+56.2	+32.3	+2.9	+8.9	+19.3	+11.6

Source: Potash and Phosphate Institute of North America.

[1] Inventory at the end of December 1987 was 1 135 190 t.

TABLE 9. CANADA, POTASH PRODUCTION AND VALUE (FORECAST 1988-2000)

	Capacity	Capacity Utilization	Production[1]	Unit Value $/t[2]		Value of Production $ millions		Implicit Price Deflator
	(000 t K_2O)	(%)	(000 t K_2O)	Current ($)	Constant (1985 $)	Current ($)	Constant (1985 $)	(1985 base)
1970	6 888	45	3 013	35	112	109	348	0.313
1971	7 522	48	3 628	37	115	134	417	0.323
1972	7 522	46	3 495	39	115	136	402	0.339
1973	7 522	59	4 454	40	108	178	481	0.370
1974	7 522	77	5 776	53	124	306	716	0.426
1975	7 522	62	4 673	77	163	360	762	0.472
1976	7 522	69	5 215	68	132	355	688	0.517
1977	7 575	76	5 764	70	127	403	732	0.553
1978	7 575	84	6 344	80	136	508	863	0.589
1979	7 850	90	7 074	104	160	736	1 132	0.650
1980	7 895	91	7 201	142	197	1 023	1 419	0.722
1981	8 060	81	6 549	152	191	995	1 251	0.795
1982	8 500	62	5 309	119	135	632	717	0.884
1983	8 980	70	6 294	103	110	648	692	0.936
1984	9 135	82	7 527	115	120	866	903	0.961
1985	9 595	69	6 661	95	95	633	633	1.000
1986	10 395	65	6 753	83	81	560	547	1.029
1987	10 890	68	7 450	100	95	745	707	1.058
1988	10 920	68	7 300	119	110	869	803	1.084
1989	10 920	72	7 900	128	115	1 011	908	1.113
1990	10 920	79	8 600	138	120	1 187	1 032	1.152
1991	10 920	82	9 000	149	125	1 341	1 125	1.190
1992	10 920	86	9 400	166	135	1 560	1 269	1.229
1993	10 920	90	9 800	172	135	1 686	1 323	1.277
1994	11 420	89	10 100	180	135	1 818	1 364	1.333
1995	11 600	90	10 400	188	135	1 955	1 404	1.390
1996	12 100	90	10 900	198	135	2 158	1 472	1.465
1997	12 600	90	11 300	206	135	2 328	1 526	1.529
1998	13 000	90	11 700	216	135	2 527	1 580	1.600
1999	13 500	90	12 100	226	135	2 735	1 634	1.677
2000	13 900	90	12 500	237	135	2 963	1 688	1.758

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[1] "Shipments" as shown by Statistics Canada as a proxy for production. [2] Value of shipments f.o.b. mine as reported by companies to Statistics Canada.

TABLE 10. WORLD POTASH PRODUCTION

	1981	1982	1983	1984	1985	1986P	1987e
				(000 tonnes K_2O)			
Brazil	-	-	-	-	-	23	30
Canada	7 147	5 352	5 930	7 749	6 637	6 697	7 267
China	20	26	25	20	20	20	25
France	1 828	1 706	1 539	1 740	1 750	1 610	1 545
Germany Dem. Rep.	3 497	3 200	3 341	3 463	3 465	3 485	3 500
Germany, Fed. Rep.	2 591	2 057	2 419	2 645	2 583	2 162	2 200
Israel	832	942	929	1 130	1 172	1 250	1 265
Italy	125	115	133	127	143	109	120
Jordan	-	9	168	291	545	662	722
Spain	728	694	659	677	645	702	740
U.S.S.R.	8 449	8 079	9 294	9 776	9 900	10 200	10 200
United Kingdom	284	240	303	319	337	391	428
United States	2 156	1 784	1 429	1 564	1 296	1 202	1 218
	27 657	24 489	26 163	29 501	28 493	28 523	29 260

Sources: International Fertilizer Industry Association Ltd.; U.S. Bureau of Mines and Energy, Mines and Resources Canada.
P Preliminary; e Estimated; - Nil.

TABLE 11. CANADA POTASH, CURRENT SITUATION AND FORECAST

	Actual							Forecast	
	1981	1982	1983	1984	1985	1986	1987e	1988	1990
				(000 tonnes K_2O)					
Capacity	8 060	8 500	8 980	9 135	9 595	10 395	10 920	10 920	10 920
Production	7 175	5 216	5 928	7 749	6 636	6 698	7 267	7 550	8 600
Capacity Utilization (%)	89	62	66	85	69	64	67	69	79
Sales:	6 337	5 101	6 557	7 071	6 577	7 023	7 837	7 700	8 600
of which: Domestic	332	283	385	436	434	322	480	450	500
United States	4 182	3 241	4 146	4 090	4 215	4 091	4 224	4 250	4 300
Offshore	1 823	1 577	2 026	2 545	1 928	2 610	3 114	3 000	3 800
End-year stocks	1 308	1 486	862	1 543	1 766	1 537	1 135	1 000	1 000
World Production	27 657	24 493	26 176	29 477	28 442	28 500	29 300	29 600	30 800
Canada/World Production Ratio (%)	26.0	21.3	22.6	26.3	23.3	23.5	24.9	25.5	28.2

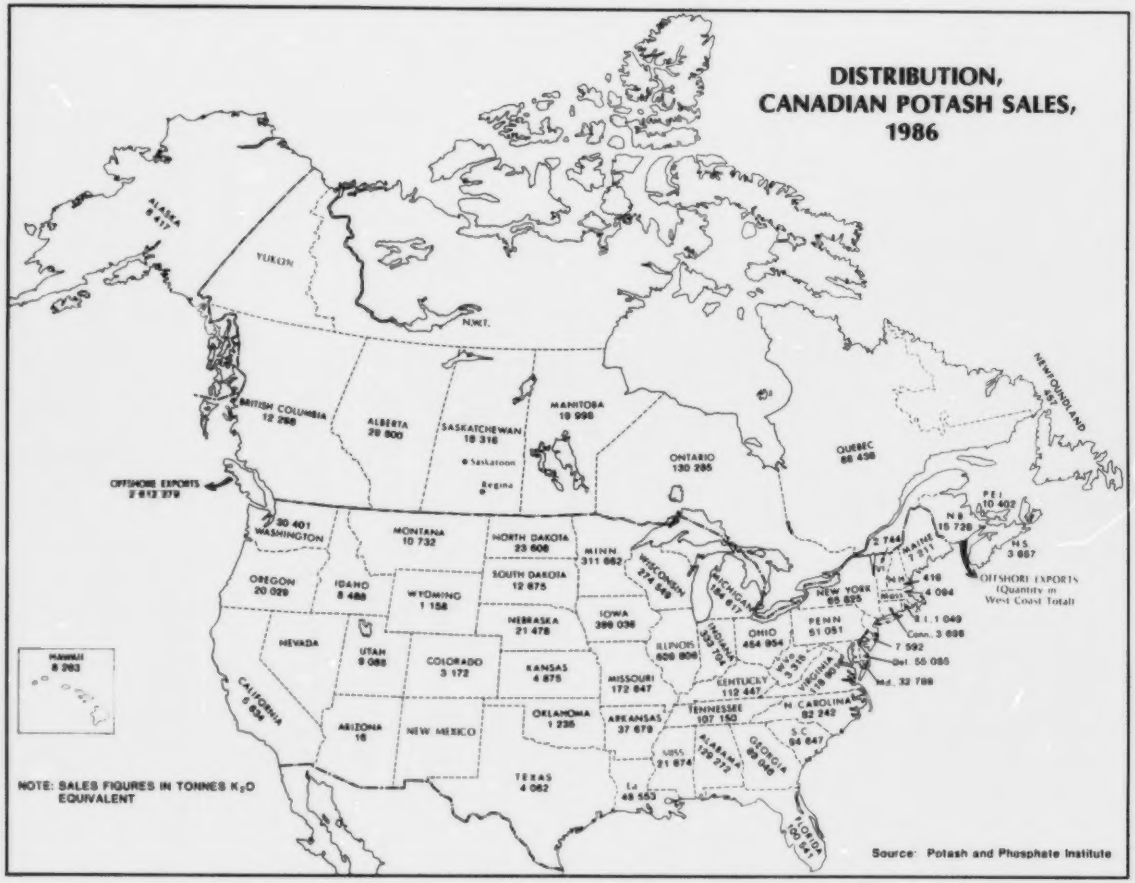
e Estimated.

TABLE 12. CANADA, POTASH MINES - CAPACITY PROJECTIONS

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
					(000 tonnes K_2O equivalent)							
Potash Corporation of Saskatchewan												
- Allen (60%)	570	570	570	570	570	570	570	570	570	570	570	570
- Cory	650	650	650	650	650	650	650	650	650	650	650	650
- Esterhazy (25% of IMC)	580	580	580	580	580	580	580	580	580	580	580	580
- Lanigan	690	690	1 240	1 740	1 740	1 740	1 740	1 740	1 740	1 740	1 740	1 740
- Rocanville	1 160	1 160	1 160	1 160	1 160	1 160	1 160	1 160	1 160	1 160	1 160	1 160
Sub-total	3 650	3 650	4 200	4 700	4 700	4 700	4 700	4 700	4 700	4 700	4 700	4 700
Central Canada Potash	815	815	815	815	815	815	815	815	815	815	815	815
Cominco Ltd.	655	815	815	815	815	815	815	815	815	815	815	815
International Minerals & Chemical Corporation (75%)	1 750	1 750	1 750	1 750	1 750	1 750	1 750	1 750	1 750	1 750	1 750	1 750
PPG Canada Inc. (Kalium)	1 055	1 055	1 055	1 245	1 245	1 245	1 245	1 245	1 245	1 245	1 245	1 245
Potash Company of America, Inc.	630	630	630	100	-	-	-	-	-	-	-	-
Saskterra Fertilizers Ltd. (Allan 40%)	380	380	380	380	380	380	380	380	380	380	380	380
Sub-total	5 285	5 445	5 445	5 105	5 005	5 005	5 005	5 005	5 005	5 005	5 005	5 005
Total Saskatchewan	8 935	9 095	9 645	9 805	9 705	9 705	9 705	9 705	9 705	9 705	9 705	9 705
Denison Mines Limited, N.B.	-	200	450	650	780	780	780	780	780	780	780	780
Potash Company of America, Inc.	200	300	300	380	380	380	380	380	380	380	380	380
Total New Brunswick	200	500	750	1 030	1 160	1 160	1 160	1 160	1 160	1 160	1 160	1 160
Canada (firm)	9 135	9 595	10 395	10 835	10 865	10 865	10 865	10 865	10 865	10 865	10 865	10 865
(unspecified)	-	-	-	-	-	-	-	-	-	-	-	500
TOTAL	9 135	9 595	10 395	10 835	10 865	10 865	10 865	10 865	10 865	10 865	10 865	11 365

Note: Capacity means "rated" capacity; under normal conditions Canadian mines operate at about 90% of rated capacity.
- Nil.

DISTRIBUTION, CANADIAN POTASH SALES, 1986


ALASKA
8 417
YUKON
N.W.T.
BRITISH COLUMBIA
12 288
ALBERTA
29 800
SASKATCHEWAN
18 316
Saskatoon
Regina
MANITOBA
19 998
ONTARIO
130 285
QUEBEC
88 436
NEWFOUNDLAND
457
P.E.I.
10 402
N.B.
15 728
N.S.
3 657
OFFSHORE EXPORTS
2 612 379
OFFSHORE EXPORTS
(Quantity in
West Coast Total)
30 401
WASHINGTON
OREGON
20 029
IDAHO
8 488
MONTANA
10 732
WYOMING
1 158
NEVADA
UTAH
9 088
COLORADO
3 172
CALIFORNIA
6 634
ARIZONA
16
NEW MEXICO
NORTH DAKOTA
23 608
SOUTH DAKOTA
12 675
NEBRASKA
21 478
KANSAS
4 875
OKLAHOMA
1 236
TEXAS
4 062
MINN
311 662
IOWA
399 036
MISSOURI
172 847
ARKANSAS
37 679
La
48 553
WISCONSIN
274 549
ILLINOIS
609 806
MISS
21 674
MICHIGAN
184 617
INDIANA
353 704
KENTUCKY
112 447
TENNESSEE
107 150
ALABAMA
129 272
OHIO
464 954
W.Va
3 316
VIRGINIA
118 80
GEORGIA
89 040
FLORIDA
100 641
S.C
84 647
N CAROLINA
82 242
PENN
51 051
NEW YORK
65 825
2 744
Vt
MAINE
7 211
N.H.
416
Mass
4 094
R.I. 1 049
Conn. 3 698
7 592
Del. 55 086
Md. 32 788
HAWAII
8 263

NOTE: SALES FIGURES IN TONNES K_2O EQUIVALENT

Source: Potash and Phosphate Institute

Salt

M. PRUD'HOMME

SUMMARY

Canada produces rock salt from four underground mines and as by-product from two potash mines. Rock salt accounts for 67% of total salt shipments. Brine is also produced in 11 plants for the manufacture of evaporated salt and chloralkalies.

In 1987, salt shipments in Canada remained stable at 10 293 700 t. The average unit value for all varieties of salt dropped by 1.3% to $22.87 a t.

In Nova Scotia, The Canadian Salt Company Limited carried out development work to prepare the 300 m level for mining at its underground operation in Pugwash. Seleine Mines Inc. in Quebec started salt extraction at the new 160 m and 173 m levels. The Quebec government announced its intention to sell Seleine's operations by late March, 1988. Seleine acquired the assets of Navigation Sonamar Inc. Navigation had an exclusive transportation contract with Seleine and the acquisition will result in substantial savings in direct transportation costs. In Ontario, Domtar Inc. resumed mining operations at Goderich in early January, following shutdown due to methane gas explosions, and started the construction of a new $10 million underground mill.

On a nine month basis, salt imports amounted to 908 633 t, a 22% drop since 1986 which was largely due to reduced imports of rock salt in Quebec and British Columbia. Imports by British Columbia accounted for 40% and were mainly from Mexico (69%), the United States (23%) and Chile (8%). For the first nine months of 1987, exports decreased by 26% to 1.4 Mt, of which 99.7% were shipped to the United States from Ontario (65%), Nova Scotia (17%), New Brunswick (12%) and Quebec (4%).

Canadian rock salt prices increased by 1.5-3.0% in 1987, ranging between $23 and $40 per t for deicing rock salt in bulk shipments, f.o.b. works in various locations in Canada.

Demand for salt will be limited to the growth of the chloralkali sector which is forecast to grow at a rate of 3% per year up to 1990 in North America. The deicing salt market is mature and pressures for substitution are mounting although to date consumption has not been substantially affected.

DOMESTIC PRODUCTION AND DEVELOPMENTS

In 1987, Canadian shipments of salt were estimated at 10 293 700 t. The average unit value of salt in all forms dropped by 1.3% to $22.87 a t.

Shipments of rock salt remained stable while exports to the United States dropped significantly. The rock salt deicing market in the United States was soft due to strong competition amongst Canadian and American producers; rock salt demand was weak because of mild winter conditions in 1986 which resulted in stock accumulation. Sales of evaporated salt improved significantly in Canada due to high operating rates prevailing in the chloralkali sector. Markets for caustic soda were strong due to demand in the pulp and paper industry. Producers of sodium chlorate in North America operated at higher rates in 1987 as demand rose in the pulp industry and in export markets. Demand for chlorine increased in chemicals and poly-vinyl chloride (PVC) plastic applications.

Atlantic region. Salt deposits occur in isolated sub-basins of a large sedimentary basin that underlies the northern mainland of Nova Scotia and extends westward under the bordering areas of New Brunswick, northeastward under Cape Breton Island, Prince Edward Island, Iles-de-la-Madeleine and southwestern Newfoundland. The salt beds occur within the Mississippian Windsor Group and are generally folded and faulted. The deposits appear to be steeply dipping tabular bodies, domes and brecciated structures of rock salt.

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Salt production in the Atlantic Provinces is from an underground rock salt mine at Pugwash, Nova Scotia, an underground potash and salt mine at Sussex, New Brunswick and a brining operation near Nappan, Nova Scotia.

In New Brunswick, Potash Company of America, Inc. produces potash and by-product salt at its underground mine near Sussex. Salt is extracted at a rate of 400 000 to 500 000 t/y and is sold mainly to the eastern United States. Reserves are estimated large enough to operate for as long as potash is extracted which is for at least 20 years. Salt is marketed for road de-icing and chemical plants. The salt grades were marketed under a sales contract to The International Salt Company of New York through Iroquois Salt Products Ltd., its Canadian subsidiary.

Denison-Potacan Potash Company produced small amounts of salt from its potash mine now under development at Salt Springs near Sussex. Salt grades are marketed locally.

In Nova Scotia, The Canadian Salt Company Limited operates an underground rock salt mine at Pugwash in Cumberland County, with a rated capacity of approximately 1 200 000 t/y. Most of the salt from this mine is used for snow and ice control. In the evaporated salt plant, saturated brine is fed to a quadruple effect vacuum pan, rated at 13 t/hr, where brine solution is evaporated to produce high quality salt crystals for use in the chemical and food industries. During 1987, development work continued to prepare the 300 m level for mining in 1990; work on the ramp and conveyor system is progressing and a sublevel at 276 m is 25% complete. Canadian Salt is considering replacing a brine evaporator to increase productivity. The company has also commissioned a study to investigate ways to expand shipping capacity at Pugwash.

Domtar Chemicals Group, division of Domtar Inc. has a brining operation at Nappan in Cumberland County. Evaporated salt products are used for table salt, fisheries and water conditioning.

Quebec. A salt deposit located on the Archipelago of Îles-de-la-Madeleine, in the Gulf of St. Lawrence, is part of the Mississippian Carboniferous Basin. Discovered in 1972, the Rocher-aux-Dauphins deposit is characterized by thick sequences of commercial salt, large sequences of rythmic salt and anhydrite cycles, abundance of low-grade potash horizons and some clay. The deposit is a typical piercement salt diapir generated by upward movements of the salt from the underlying anticlinal structure. It contains about 4 billion t of raw salt of which a quarter is above 97% sodium chloride. The salt lies between 30 m and 75 m underneath the surface. The deposit dips about 55° to the southwest. Reserves are 460 Mt of which 34.2% are mineable, grading an average of 94.5% NaCl.

Seleine Mines Inc., a subsidiary of the Société québécoise d'exploration minière (SOQUEM), mines rock salt commercially at its underground operation which has a production capacity of 1.4 Mt/y, and reserves sufficient for 20 years. All salt produced is for de-icing purposes and is shipped to mainland Quebec, Atlantic Provinces and northeastern United States.

During 1987, Seleine initiated modifications on its crushing facilities by installing two mobile primary crushers. Salt extraction started at the newly developed 160 m and 173 m levels; full scale operation is expected by the end of 1988 when the mineable reserves at the 210 m and 223 m levels are exhausted. Late in 1987, the Quebec government announced its intention to sell its wholly-owned rock salt mine. Long-term contracts will be maintained whereas the Quebec Department of Transportation is bound to source 90% of its requirements for deicing rock salt from Seleine up to the year 1992; Seleine also has a contractual agreement to supply a U.S. distributor with up to 300 000 t/y. The deadline for tenders has been set for January 22, 1988 for the sale to be concluded by the end of March 1988. The sale is conditional on continuation of the operation for at least 10 years, the establishment of the head-office in the Province of Quebec and maintenance of the current labour contract; job security is a prerequisite to approval of the sale. In 1987, Seleine bought the assets of Navigation Sonamar Inc. for $4.5 million which had an exclusive transportation contract with them. The acquisition will result in savings of about $700 000 per year in direct transportation costs.

Ontario. Thick salt beds underlie much of southwestern Ontario, extending from Amherstburg northeastward to London and Kincardine, bordering on what is known geologically as the Michigan Basin. As many as six salt beds, occurring in the Upper Silurian Salina Formation at depths from 275 to 825 m, have been identified and traced from drilling records. Maximum bed thickness is 90 m, with aggregate thickness reaching as much as 215 m. The beds are relatively flat-lying and undisturbed, resulting in low-cost mining.

During 1987, those beds were worked through two rock salt mines, one at Goderich and one at Ojibway, and through brining operations at Goderich, Sarnia, Windsor and Amherstburg.

At Goderich, Domtar Chemicals Group operates an underground rock salt mine. In early January, the mining operations resumed following the shutdown in late 1986 due to a localized cave-in caused by a methane gas explosion. During 1987, Domtar started the construction of a new $10 million mill and restored access to development areas where cave-ins occurred last year. The usual maintenance shutdown during March lasted six weeks allowing extra time for restoring roof support over the underground crushing facilities. Domtar's salt is marketed mainly for ice control and it is sold mainly in eastern Canada, in the north central United States, and in regions accessible through the Mississippi River system. Evaporated salt is also produced at the Domtar brining operation located near Goderich.

At Sarnia, Dow Chemical Canada Inc. produces brines from wells for the production of caustic soda and chlorine.

The Canadian Salt Company Limited produces both rock salt from the Ojibway underground mine and vacuum salt products from brine wells near Windsor. The total rated capacity for rock salt is more than 2.5 Mt/y. Rock salt is extracted from the Middle F - Unit at a depth of 297 m while brine is pumped from the B - Unit at depths of 427 m and 457 m.

In the vicinity of Amherstburg, General Chemical, a division of General Chemical Canada Ltd., operates a brining operation for the manufacture of soda ash and by-product calcium chloride.

Prairie Provinces. Salt beds underlie a broad belt of the Prairie Provinces extending from the extreme southwestern corner of Manitoba, northwestward across Saskatchewan and into the north-central part of Alberta. Most of the salt deposits occur within the Prairie Evaporite Formation, which constitutes the upper part of the Middle Devonian Elk Point Group, with thinner beds of salt occurring in Upper Devonian rocks. Depths range from 180 m at Fort McMurray, Alberta, to 900 m in eastern Alberta, central Saskatchewan and southwestern Manitoba, and to 1 830 m around Edmonton, Alberta, and in southern Saskatchewan. Cumulative thicknesses reach a maximum of 400 m in east-central Alberta. The beds lie relatively flat and undisturbed. The same rock sequence contains a number of potash beds currently under exploitation in Saskatchewan.

In Saskatchewan, four companies produce salt from the Middle Devonian Prairies formation. International Minerals & Chemical Corporation (Canada) Limited (IMCC) supplies by-product rock salt from its potash operation at Esterhazy. Its salt is distributed locally for road de-icing by Kleysen Transport Company. Domtar Inc. operates a brining operation, near Unity, for the production of fine vacuum pan salt; Unity has the sole fused salt facility operating in Canada as other salt operations switched to salt pelletizing through compaction. The Canadian Salt Company Limited at Belle Plaine produces table salt from by-product brine from an adjacent potash solution mine operated by Kalium Chemicals, a division of PPG Canada Inc.; PPG has reached an agreement to sell its potash operations to Sullivan and Proops of Chicago, Illinois. Saskatoon Chemicals, a division of Weyerhaeuser Canada Ltd., produces brines from wells near Saskatoon for the manufacture of caustic soda and chlorine, mainly used by pulp producers as a bleaching agent.

In Alberta, two producers operate brining operations: at Fort Saskatchewan near Edmonton, Dow Chemical Canada Inc. produces salt brine for the manufacture of chloralkali chemicals; and, at Lindberg, The Canadian Salt Company Limited produces fine vacuum pan salt.

In Alberta, salt deposits are still being investigated for underground storage caverns where potential exists for further development.

British Columbia. There is no production of salt in this province where three companies operate six chloralkali plants; solar salt is imported from Mexico, the United States and Chile.

CONSUMPTION AND TRADE

Consumption. Canadian consumption of all types of salt in 1986 has been estimated at 8 079 200 t, a 1.1% increase over 1985. Snow and ice control accounted for 48.8% of total consumption, followed by industrial chemicals (47.2%).

Worldwide, salt is largely used as a chemical raw material accounting for 60% of world consumption, followed by table salt with 17%, road de-icing with 10%; and the remainder 13% for animal feed and water treatment. However, the pattern for consumption differs in North America where the chemical industry consumes about half of total production, followed by highway usage and the food industry.

The largest consumer of salt is the industrial chemicals industry, particularly for the manufacture of chloralkali such as caustic soda (sodium hydroxide), chlorine and soda ash (sodium carbonate). Salt for four caustic soda and chlorine plants in Canada is obtained from on-site brining and natural brines; others use mined rock salt or imported solar-evaporated salt. Other industrial chemicals that require significant quantities of salt include sodium chlorate, sodium bicarbonate, sodium chlorite and sodium hypochlorite.

Consumption for snow and ice control varies from year to year, depending on weather conditions. For the past nine years, the average proportion for this purpose in Canada was about 45% of total consumption, compared to 24% for the United States and 14% in western Europe. On a world basis, this application accounts for 10% of total world salt consumption. For road de-icing, the American Society for Testing and Materials (ASTM) provides standard specifications for sodium chloride: D632-72 (78). Rates of application are controlled by several factors such as precipitation, temperature, wind effects, traffic density and road conditions.

Rock salt is the most widely used de-icing agent in North America. However, the widespread uncontrolled use of deicing salt increases the risks of corrosion and environmental degradation. These concerns have led to research in the field of salt alternatives for snow and ice control. Mixtures with sand, calcium chloride and salt have been tested in some countries. Chemical alternatives such as Calcium-Magnesium Acetate (CMA) and Sodium Formate (NaFo) are being experimented in North America.

During the winter of 1986-87, trial tests for alternative chemical de-icers were carried out by the City of Ottawa, and by the Ontario Ministry of Transportation and Communications. CMA and NaFo have shown promising results but costs are currently prohibitive since CMA and NaFo cost respectively about 35 and 17 times as much as salt.

The adverse effects of salt have been recognized by the Salt Institute of Washington which presents information seminars on salt damages to highways, streets and infrastructures, on proper storage and spreading methods.

Other sectors which consume salt include the food industry, animal diet, fishery industry and water treatment which together account for less than 10% of total Canadian consumption. Slight growth in these markets should continue in the short term although there is pressure in the food industry to use less salt for health reasons.

In Canada, a salt producer initiated the sale of a new substitute for table salt; the product is a mixture of iodized sodium chloride and potassium chloride which results in lower sodium intake. In the United States, potassium chloride is being promoted as a substitute for sodium chloride for use as a regenerant material in water softeners; however this product costs 3 to 4 times as much as salt and 25% more is required to treat the same amount of water.

Trade. Salt imports in 1986 rose 5.8% to 1 328 300 t. The average unit value for imported salt remained stable at $19.64 a t.

On a nine month basis, 1987 imports amounted to 908 633 t, a 22% drop compared to the same period in 1986; 1987 exports dropped by 26% in terms of tonnage and by 16% in terms of value. Imports were mainly shipped to Ontario (40%), British Columbia (40%) and Quebec (11%), while exports originated from Ontario (65%), Nova Scotia (17%), New Brunswick (12%), and Quebec (4%).

WORLD PRODUCTION AND REVIEW

World production of salt in 1986 remained stable at 174 Mt. Salt is produced in about 100 countries which are mostly self-sufficient for their consumption requirements. The United States remained the leading producer of salt, accounting for 19% of world production, followed by China (10%), the U.S.S.R. (9%), West Germany (6%), and Canada (6%).

United States. In 1987, total production of all types of salt decreased 3% to 32.6 Mt and reported sales totalled 32.3 Mt. Apparent consumption dropped slightly by 3% to 37 Mt; the decline in production and consumption resulted from the carryover of high inventories from 1986, coupled with reduced demand for highway salt. Also, the chloralkali industry required less salt due to rationalization over the last three years. Salt imports decreased by 16% to 5.08 Mt and were mainly from Mexico (27.8%), Canada (27.7%) and the Bahamas (15.6%). Salt exports dropped significantly by 44% to 600 000 t, of which 98% were shipped to Canada where demand for foreign salt declined due to the competitiveness of local rock salt suppliers.

The average unit value of bulk rock salt rose 2% to US$14.75 per short ton. Salt in the United States is mainly used for the production of chloralkali (49%), ice control (26%), general industrial products (5%), agriculture (3%), and food processing (3%). Rock salt accounted for 34% of total U.S. consumption of rock salt.

The International Salt Company of Clarks Summit, Pennsylvania, announced its intention to buy the salt operations of Diamond Crystal Salt Company in St. Clair, Michigan for US$65 million. The sale would include evaporated salt plants in St. Clair and Ministec (Michigan), Akron (Ohio) and Williston (North Dakota) and a solar salt facility. The sale has to be cleared by the Antitrust division of the U.S. Justice Department.

In early 1987, Diamond Crystal Salt Company reached an agreement with AMAX Inc. to acquire the assets of Sol-Aire Salt & Chemical Co., located at Lake Point, Utah. Diamond Crystal intends to invest US$13 million to build a major solar salt operation. Construction began in 1987 and salt production is expected to start in 1988 for use in ice control and water treatment.

Occidental Petroleum Corporation (Oxy Pete) and E.I. du Pont de Nemours and Company signed a letter of intent under which Occidental Chemical Corporation (Oxy Chem), a subsidiary of Oxy Pete, would acquire E.I. du Pont's idle chloralkali facility at Corpus Christi, Texas. The US$100-125 million plant will allow Oxy Pete to increase its chlorine production capacity by 1 145 t/d and its caustic soda capacity by 1 290 t/d. The plant should resume activity during the second quarter of 1988 and reach full production by year's end.

Olin Corp. and E.I. du Pont de Nemours and Company completed the construction of a 230 000 t/y chloralkali plant in Niagara Falls, New York. The US$150 million facility, called Niachlor, uses membrane technology and should be in production by early 1988.

China. A large salt deposit has been discovered in the north-east Jiangsu Province. Reserves which have been quoted to be the largest in China were estimated at 200-400 000 Mt. The deposit lies at depths of 600 to 2 000 m below surface in beds up to 100 m thick. A commercial scale venture is currently being considered.

United Kingdom. Development work is being carried out at the Meadowbank underground salt mine at Whatcroft, near Winsford. The facility is operated by the Mond division of Imperial Chemical Industries plc (ICI) and produces around 1.8-2 Mt of 92% NaCl, mainly used for ice and snow control. The project will expand reserves by 19 Mt of salt and give access to new production faces.

INTERNATIONAL TRADE

Salt is a widespread, low value and bulk commodity. It is relatively cheap to extract and transportation represents a significant proportion of the total delivered price of salt. As a result, international trade in salt is small relative to world production, i.e., 27 Mt which is about 15% of total world production. Major international routes consist of cross-border trade and trade within geographical areas. The cross-border trade between Canada and the United States account for 11% of world total, between Mexico and the United States for 10%. Trade within western Europe which involves the Scandinavian countries, the Netherlands, France, Benelux, Poland, Italy, East and West Germany accounts for 26% of world total. Trade to the Pacific area accounts for about 34% of world total.

PRICE

Salt is not a standard commodity and its price ranges depend on such factors as production methods, purity, scale of operations and transportation costs.

In 1987, Canadian rock salt prices, bulk, f.o.b. works, for de-icing purposes rose 2.5-3.0% and ranged between $23 and $40 a t. Prices, f.o.b. works, in the Atlantic Provinces were around $40-42 a t, in Quebec $50-60 a t, in Ontario $40-42 a t, and in western Canada $41-45 a t. Fine evaporated salt prices rose an average of 2.7% and varied between $86 and $110 a t. Fishery grade was sold for $91-110 a t, and water conditioner grade for $6-9 per 40 kg bag.

OUTLOOK

Canada is de facto self-sufficient in salt since our exports exceed our imports. Eastern Canadian requirements of rock salt are served locally while imports serve western Canada's needs for chloralkali plants in British Columbia. Current capacity is sufficient to meet any forecast increase in demand for the next decade.

The industrial chemicals industry is a sector of consumption which is likely to undergo strong growth especially in the production of chloralkali such as caustic soda, chlorine, sodium carbonate and sodium chlorate.

Caustic soda consumption is highly dependent on growth in the pulp and paper industry. Caustic soda demand for pulp bleaching and waste water treatment is expected to benefit from the forecast rise in pulp output and to continue to grow at an annual rate of 2.5-3.5% up to 1990.

Chlorine demand is expected to match the strong demand for poly-vinyl chloride (PVC) and vinyl chloride monomer (VCM), and for pulp bleaching. In North America, several pulp mills have initiated conversion from chlorine pulp bleaching to the chlorine dioxide process which consumes sodium chlorate. Moreover, environmental concerns may arise in the near future over the presence of dioxin in the waste water of some pulp and paper mills in the United States. Growth in chlorine demand in North America is forecast at an annual rate of 3% through 1990.

The market for de-icing salt within North America is maturing. A slow growth rate is expected due to increasing environmental concerns which have led to research to find substitutes.

In the food industry, salt is a major supplement and a widely-used preservative. Its demand is linked to population growth and should increase slightly. An annual global average growth rate of 1.2% is forecast for the next two decades by the U.S. Bureau of Mines. Concerns related to high sodium diet will likely result in the introduction of sodium chloride substitutes.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
CANADA					
92501-1	Common salt (including rock salt; sea salt and table salt)	free	free	5¢/100 lb.	free
92501-2	Salt for use of the sea or gulf fisheries	free	free	free	free
92501-3	Table salt made by the admixture of other ingredients when containing not less than 90% of pure salt	4.0	4.0	15	2.5
92501-4	Salt liquors and sea water	free	free	free	free
UNITED STATES, (MFN)					
420.92	Salt in brine		3.7		
420.94	Salt in bulk		free		
420.96	Salt, other		free		

Sources: The Customs Tariff, 1987, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1987), USITC Publication 1910; U.S. Federal Register.

TABLE 1. CANADA, SALT SHIPMENTS AND TRADE, 1985-87

	1985		1986		1987P	
	(tonnes)	($)	(tonnes)	($)	(tonnes)	($)
Shipments						
By type						
Mined rock salt	6 608 739	120 514 399	6 867 287	149 250	..	..
Fine vacuum salt	805 209	79 702 911	815 044	74 471	..	..
Salt content of brines used or shipped	2 670 749	15 144 460	2 649 515	15 745	..	..
Total	10 084 697	215 361 770	10 331 846	239 465 638	10 293 700	235 419 700
By province						
Nova Scotia	..	..	x	x	..	..
New Brunswick	..	..	x	x	..	..
Quebec	..	..	x	x	..	..
Ontario	5 828 762	125 233 440	6 240 440	147 523 399	5 723 700	140 489 000
Saskatchewan	437 410	24 436 993	473 316	25 758 704	448 000	24 506 000
Alberta	1 403 500	17 995 013	1 303 879	14 216 000	..	..
Total	10 084 697	215 361 770	10 331 846	239 465 638	10 331 846	235 419 700
		($000)		($000)		($000) (Jan. - Sept.)
Imports						
Salt, wet in bulk						
Mexico	309 122	3 200	288 826	3 779	251 236	3 084
United States	232 568	3 651	18 843	293	42 151	624
Other	0	0	0	0	72	1
Total	541 690	6 851	307 669	4 072	293 459	3 709
Salt, domestic						
United States	10 891	2 000	10 925	1 970	30 136	1 622
Switzerland	83	55	220	37	14	37
Netherlands	2	10	53	26	95	16
Other countries	78	12	150	33	94	22
Total	11 054	2 077	11 350	2 066	30 339	1 697
Salt, n.e.s.						
United States	554 926	14 107	832 618	17 695	505 974	12 220
Spain	35 660	624 000	25 809	470	23 620	389
Chile	59 572	616 000	109 515	1 161	27 500	293
Bahamas	51 742	828	14 244	246	27 012	498
Other countries	874	40	27 084	388	716	41
Total	702 774	16 215 000	1 009 270	19 960	584 822	13 441
Salt and brine by province of clearance						
Newfoundland	39 144	737	39 621	739	33 512	612
Nova Scotia	17 571	271	3 506	59	17 141	279
New Brunswick	1	..	3 872	74	53	10
Quebec	196 587	3 290	304 471	4 979	106 833	2 024
Ontario	448 330	11 190	407 217	9 443	370 878	8 432
Manitoba	4 959	331	3 840	287	1 799	133
Saskatchewan	5 268	523	6 959	768	8 386	630
Alberta	8 513	681	7 220	549	4 664	333
British Columbia	535 145	8 120	551 594	9 200	365 367	6 395
Total	1 255 518	25 143	1 328 300	26 098	908 633	18 847
Exports						
Salt and brine						
United States	2 257 550	28 566	2 494 989	35 798	1 324 836	22 739
Leeward-Windward Islands	1 500	237	1 549	162	787	85
Guyana	1 600	150	0	0	-	-
Other countries	2 426	318	5 988	524	3 421	336
Total	2 263 076	29 272	2 502 526	36 484	1 329 044	23 160

Sources: Statistics Canada; Energy, Mines and Resources Canada.
P Preliminary; .. Not available; n.e.s. - Not elsewhere specified; x Confidential.
Note: Totals may not add up due to rounding.

TABLE 2. CANADA, SUMMARY OF SALT PRODUCING AND BRINING OPERATIONS, 1985 AND 1986

Company	Location (Initial Production)	Annual Production Capacity	Production[1] 1986P (1985)	Employment 1986P (1985)	Remarks
		(000 tonnes)			
Nova Scotia					
The Canadian Salt Company Limited	Pugwash (1959)	1 200	803.2 (684.0)	184[3] (166)	Rock salt mining to a depth of 253 m.
	Pugwash (1962)	110	77.7 (82.3)		Dissolving rock salt fines for vacuum pan evaporation.
Domtar Inc.	Nappan (1947)	90	68.6 (58.0)	80 (81)	Brining for vacuum pan evaporation.
New Brunswick					
Potash Company of America, Inc.	Sussex (1980)	500	480.5 (475.5)	32[2] (32)	By-product rock salt from potash mine for use in snow and ice control.
Quebec					
Seleine Mines Inc.	Îles-de-la-Madeleine (1982)	1 400	1 070.0 (997.0)	203 (206)	Rock salt mining to a depth of up to 273 m.
Ontario					
General Chemical Canada Ltd.[4]	Amherstburg (1919)	670	670.0 (618.1)	8[2] (8)	Brining to produce sodium carbonate.
The Canadian Salt Company Limited	Ojibway (1955)	2 500	2 341.0 (2 408.0)	215 (219)	Rock salt mining at a depth of 300 m.
	Windsor (1892)	150	131.8 (140.0)	115 (145)	Brining, vacuum pan evaporation.
Domtar Inc.	Goderich (1959)	2 800	2 578.0 (1 838.0)	335 (338)	Rock salt mining at a depth of 536 m.
	Goderich (1880)	120	97.9 (98.0)	70 (73)	Brining for vacuum pan evaporation.
Dow Chemical Canada Inc.	Sarnia (1950)	800	776.1 (789.0)	4[2] (4)	Brining to produce caustic soda and chlorine.
Prairie Provinces					
International Minerals & Chemical Corporation (Canada) Limited	Esterhazy, Sask. (1962)	120	114.9 (91.9)	3 (3)	By-product rock salt from potash mine for use in snow and ice control.
The Canadian Salt Company Limited	Belle Plaine, Sask. (1969)	170	117.9 (120.9)	30 (24)	Producing fine salt from by-product brine from nearby potash operation.
Domtar Inc.	Unity, Sask. (1949)	180	165.6 (163.0)	85 (88)	Brining, vacuum pan evaporation, and fusion.
Saskatoon Chemicals	Saskatoon, Sask. (1968)	70	66.7 (55.1)	5[2] (5)	Brining to produce caustic soda, chlorine and sodium chlorate.
The Canadian Salt Company Limited	Lindbergh, Alta. (1968)	140	137.4 (138.3)	70 (77)	Brining, vacuum pan evaporation.
Dow Chemical Canada Inc.	Fort Sask., Alta. (1968)	1 400	977.1 (1 241.9)	3[2] (3)	Brining to produce caustic soda and chlorine.
		12 420	10 674.4 (9 999.0)	1 442 (1 472)	

Sources: Mineral Policy Sector, Energy, Mines and Resources Canada; Industry's representatives.

[1] Shipments. [2] Employment part of chemical complex. [3] Includes employment in brining operations. [4] Formerly Allied Canada Inc.

P Preliminary.

TABLE 3. CANADA, SALT SHIPMENTS AND TRADE, 1980-87

	Producers' Shipments					
	Mined Rock	Fine Vacuum	In Brine and Recovered in Chemical Operations	Total	Imports	Exports
			(tonnes)			
1980	4 507 416	781 428	2 134 010	7 422 854	1 151 203	1 637 601
1981	4 371 314	764 037	2 107 243	7 242 594	1 254 992	1 507 710
1982	5 223 073	773 086	1 944 172	7 940 331	1 526 879	1 721 893
1983	5 846 994	714 464	2 040 925	8 602 383	814 250	1 914 629
1984	7 030 664	754 675	2 450 060	10 235 399	1 053 217	2 530 038
1985	6 608 739	805 209	2 670 749	10 084 697	1 255 518	2 263 076
1986	6 867 287	815 044	2 649 515	10 331 846	1 328 298	2 502 513
1987P	..	..	..	10 293 700	..	..

Sources: Statistics Canada; Energy, Mines and Resources Canada.
P Preliminary; .. Not available.

TABLE 4. CANADA, AVAILABLE DATA ON SALT CONSUMPTION, 1983-86

	1983	1984	1985P	1986[e]
		(tonnes)		
Snow and ice control[1]	2 712 088	3 560 809	3 796 153	3 943 700
Industrial chemicals[2]	3 226 558	3 586 487	3 870 616	3 821 000
Fishing industry	55 000	58 000	69 000	55 000
Food processing				
Fruit and vegetable processing	14 887	18 269	18 775	19 000
Bakeries	12 686	11 947	11 313	13 000
Fish products	28 281	24 071	30 459	30 000
Dairy products	10 130	10 484	10 799	11 000
Biscuits	1 981	2 040	2 153	2 000
Miscellaneous food preparation	21 863	24 787	24 325	25 000
Grain mills[3]	64 289	64 254	66 482	68 000
Slaughtering and meat processors	32 889	29 557	30 646	33 000
Pulp and paper mills	30 205	30 048	35 327	34 000
Leather tanneries	5 137	7 948	6 617	7 000
Miscellaneous textiles	4 287	3 758	3 633[4]	4 000
Breweries	512	333	508	500
Other manufacturing industries	13 857	11 287	12 339	13 000
Total	6 243 650	7 444 079	7 989 345	8 079 200

Sources: Statistics Canada; Salt Institute.
[1] Fiscal year ending June 30. [2] Includes rock salt, fine vacuum salt and salt contained in brine. [3] Includes feed and farm stock salt in block and base forms. [4] Estimated, data no longer available.
[e] Estimated by Energy, Mines and Resources Canada; P Preliminary.

TABLE 5. CHLORALKALI PLANTS IN CANADA, 1987

Company	Location	Parent Company	Plant Location	Type of Cells	Products	Capacity (tonnes)	Remarks
Alby Chlorate Canada Inc.	Valleyfield, Quebec	Alby Klorat AB, Sweden Olin Corp., U.S.A.	Valleyfield, Quebec	-	sodium chlorate	50 000	Operation started in September 1986.
B.C. Chemicals Ltd.	Prince George, British Columbia	B.C. Chemicals Ltd., Prince George, B.C.	Prince George, British Columbia	-	sodium chlorate	33 000	Captive production.
BCM Technologies Inc.	Amherstburg, Ontario	BCM Technologies Inc., Amherstburg, Ontario	Amherstburg, Ontario	-	sodium chlorate	50 000	
Canadian Occidental Petroleum Ltd.	Calgary, Alberta	Occidental Petroleum Corporation, Los Angeles, CA U.S.A.	Brandon, Manitoba	-	sodium chlorate	17 500	6 500 t expansion completed in 1987, using metal anode technology.
			Nanaimo, British Columbia	- diaphragm	sodium chlorate caustic soda chlorine	8 000 31 000 28 000	
			North Vancouver, British Columbia	diaphragm	caustic soda chlorine	155 000 141 000	
			Squamish, British Columbia	-	sodium chlorate	11 000	
			Squamish, British Columbia	mercury	caustic soda chlorine	75 000 68 000	Bought from FMC of Canada Limited in early 1987.
Canso Chemicals Limited	New Glasgow, Nova Scotia	C-I-L Inc., North York, Ontario	Abercrombie Point, Nova Scotia	mercury	caustic soda chlorine	20 000 18 000	
C-I-L Inc.	Willowdale, Ontario	Imperial Chemical Industries plc, England	Bécancour, Quebec	diaphragm	caustic soda chlorine	325 000 295 000	
			Cornwall, Ontario	mercury	caustic soda chlorine	38 500 35 000	
			Dalhousie, New Brunswick	mercury	caustic soda chlorine	31 000 28 000	
Dow Chemical Canada Inc.	Sarnia, Ontario	The Dow Chemical Company, Michigan, U.S.A.	Fort Saskatchewan, Alberta	diaphragm	caustic soda chlorine	524 000 476 000	
			Sarnia, Ontario	diaphragm	caustic soda chlorine	350 000 318 000	

ERCO Division of Tenneco Canada Inc.	Islington, Ontario	Tenneco, Inc., Texas, U.S.A.	Buckingham, Quebec	-	sodium chlorate	33 000	The old graphite cells plant of 55 000 t capacity closed late in 1986. The 44 000 t/y capacity expansion will come on stream by the end of 1988.
			North Vancouver, British Columbia	-	sodium chlorate	54 000	A $15 million expansion will add 22 500 t/y from changes to high efficiency metal cells, and will be completed in 1989. The old 44 000 t graphite cells will be used only for surge demand.
			Thunder Bay, Ontario	-	sodium chlorate	46 000	
Great Lakes Forest Products Limited	Thunder Bay, Ontario	Canadian Pacific Enterprises Limited Montreal, Quebec	Dryden, Ontario	membrane	caustic soda chlorine	16 000 14 500	
PPG Canada Inc. Industrial Chemical Division	Toronto, Ontario	PPG Industries, Inc. Pittsburg, Penn., U.S.A.	Beauharnois, Quebec	-	sodium chlorate	40 000	40 000 t idled in late 1986.
				mercury	caustic soda chlorine	67 000 61 000	
QueNord Inc.	Magog, Quebec	Kema-Nobel AB, Sweden	Magog, Quebec	-	sodium chlorate	92 000	Increased capacity in 1987, with high efficiency cells.
St. Anne-Nackawic Pulp & Paper Co. Ltd.	Nackawic, New Brunswick	Parsons & Whittemore, Inc. New York, U.S.A.	Nackawic, New Brunswick	-	sodium chlorate	9 000	Captive production.
				membrane	caustic soda chlorine	10 000 9 000	
Saskatoon Chemicals	Saskatoon, Saskatchewan	Weyerhaeuser Canada Ltd. Kamloops, B.C.	Saskatoon, Saskatchewan	-	sodium chlorate	25 000	
				membrane	caustic soda chlorine	36 000 33 000	

Sources: Energy, Mines and Resources Canada, Mineral Policy Sector; Department of Regional Industrial Expansion (Ottawa), Chemicals Directorate; Ministère de l'Industrie, du Commerce et du Tourisme du Québec; September 1987.
- Nil.

TABLE 6. WORLD SALT PRODUCTION, 1982-86

Countries	1982	1983	1984[r]	1985P	1986[e]
			(000 tonnes)		
United States	34 355	31 385	35 580	36 340	33 250
China[e]	15 965	16 125	16 280	14 440	17 300
U.S.S.R.[e]	15 420	16 200	16 510	16 100	16 050
West Germany	11 520	10 400	12 210	13 070	11 160
Canada	8 070	8 615	10 310	10 000	10 690
India	9 980	7 010	7 720	9 870	9 980
France	6 650	6 950	7 150	7 110	7 080
United Kingdom	6 895	6 310	7 130	7 140	7 070
Mexico	7 980	5 700	6 160	6 470	6 530
Australia	5 625	5 170	5 280	6 170	6 170
Romania	4 750	4 590	4 870	5 020	4 990
Poland	4 260	3 625	4 710	4 860	4 900
Italy	4 530	4 540	3 980	3 750	4 030
Other	32 700	32 500	34 700	33 330	34 750
Total	168 700	159 120	172 590	173 670	173 950

Source: U.S. Bureau of Mines, 1987.
P Preliminary; [e] Estimated; [r] Revised.

Selenium and Tellurium

W. McCUTCHEON

SELENIUM

Selenium is a nonmetallic element chemically similar to sulphur but with some of the properties of a metal. Selenium occurs in minerals associated with sulphides of copper, lead and iron. Commercial production originates principally from electrolytic copper refinery slimes as well as from flue dusts of copper and lead smelters. A significant amount of selenium is also recovered from secondary sources. In 1986, western world primary production was estimated to be about 1400 t whereas consumption was about 1600 t. Secondary production was estimated at about 140 t.

CANADIAN DEVELOPMENTS

Selenium is recovered in Canada as a by-product of primary and secondary copper refining. Annual production (Table 2) varies according to copper refinery operating rates and recoveries, and according to the market for selenium. Xerographic scrap and other selenium scrap are imported from the United States and other countries to be refined in Canada. Canadian primary selenium production in 1987 is estimated at 345 t, the same as 1986. Production in 1988 is forecast at 355 t. Production in 1986 and 1987 was affected by the strike at Noranda Inc.'s Horne smelter which lasted from November 1986 to February 1987.

Noranda Inc.'s CCR Division copper refinery at Montreal East, Quebec, operates the world's largest selenium recovery plant. The copper refinery processes copper anodes from the company's Horne and Gaspé smelters in Quebec and from the Flin Flon smelter of Hudson Bay Mining and Smelting Co., Limited in Manitoba. The selenium recovery unit also handles anode slimes from the copper refinery at Kidd Creek Mines Ltd. Noranda produces commercial-grade (99.5%) and high-purity (99.99%) selenium and a variety of selenium compounds. Nominal annual capacity is about 325 t of primary selenium in elemental form and in salts, depending upon the selenium content of the anode copper processed. In addition, production capacity of secondary selenium is nominally 165 t/y, but this too depends upon the selenium content of the feed material.

The capacity of INCO Limited's selenium recovery plant at Copper Cliff, Ontario is 67 t/y of minus 200 mesh selenium powder (99.5% Se).

Canada consumes only a small amount of its refined selenium production, principally in the glass industry. Most Canadian selenium is exported to the United States and to the United Kingdom, with minor amounts to the rest of Europe.

WORLD DEVELOPMENTS

Consumption of selenium in the western world was estimated at about 1600 t for 1986, almost unchanged from 1985.

Selenium-producing countries include the United States, Canada, Japan, the U.S.S.R., Belgium, Sweden, Mexico, Yugoslavia, Finland, Peru, Australia, and Zambia. Total western world primary production is estimated at about 1400 t. Expansion of Belgian production capacity from 260 t/y to 360 t/y was deferred from mid-1987 until 1988.

In the United States, ASARCO Incorporated, Phelps Dodge Corporation and BP America Inc.'s Kennecott operation produce selenium. Kennecott's selenium production facilities were closed from mid-1985 to late 1987. Because there were only two remaining significant U.S. producers, U.S. production and consumption data for 1985 to 1987 was withheld. According to the U.S. Bureau of Mines, the main end-use by industrial categories in 1983 were: electronic and photocopier components, 33%; glass manufacturing, 27%; pigments, 20%; metallurgical applications, 7%; other including animal feed and chemicals, 13%.

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Imports of selenium by the People's Republic of China increased significantly in 1986, to an estimated 150 t. Lack of United States, Belgian, Australian, German and U.S.S.R. data makes data for selenium production and consumption incomplete. Estimates of these countries' production are available from proprietary sources.

PRICES

Producer prices have not been published since early 1981. Metals Bulletin Inc. prints a "European Free Market" price spread for selenium. Table 3 presents the monthly high and low European Free Market prices for 1986 and 1987. As these prices reflect an estimated 5% of the commercial grade selenium sold, they are more volatile than producers' prices. Producer prices are not public, but estimates for prices in 1986 were in a range of US$13 to $18/lb. for high purity selenium and US$5 to $7.50 for commercial grade selenium. Published prices in 1987 increased rapidly towards year end to over US$9/lb.

USES

Selenium is used in the manufacture of glass, steel, electronic components, explosives, batteries, animal and poultry feeds, fungicides and pigments, and in xerography.

The photoreceptor industry is the major user of selenium. Fully panchromatic organic photoreceptors and amorphorus silicon photoreceptors have the potential to substitute for selenium. However, laser printers do not use selenium. The rapidly increasing laser printer market will reduce the growth potential for xerography, and thus for growth in selenium consumption. Further price reductions in laser printing equipment and operating costs are expected to seriously impinge on the selenium market by the early 1990s.

Other industrial uses for selenium include: decolourization of glass; improved machineability of steel castings; pigmentation for ceramics, plastics and coatings; catalytic uses; and blasting caps. Selenium is also used as a food supplement, primarily for animals. In April 1987, the U.S. Food and Drug Administration tripled the allowable selenium content in feed. In Sweden, a selenium compound was added to a mercury-contaminated lake and subsequently mercury levels in fish were observed to be reduced by a factor of 2 to 4.

Elemental selenium is marketed in two grades: commercial, with a minimum content of 99.5% Se; and high purity, with a minimum content of 99.99% Se. Other forms include ferroselenium, nickel-selenium, selenium dioxide, barium selenite, sodium selenate, sodium selenite and zinc selenite.

OUTLOOK

Selenium is associated with copper minerals and hence its production is dependent upon primary copper production. EMR projects future copper consumption to increase at a rate of between 1.2% and 1.6% annually until the end of the century. The ratio of selenium to copper is lower in porphyry copper deposits than in the polymetallic deposits such as occur in eastern Canada, Sweden and Australia which produce both copper and selenium. As the proportion of primary copper production in the western world is shifting in favour of large porphyry deposits, the amount of selenium produced per unit of copper will decrease. Thus, by-product selenium product is forecast to grow at a rate of about 1% annually.

Given higher prices, production could be increased by improving selenium recovery from the present level of between 50 and 60%. Selenium recovery is also likely to increase slightly due to more stringent emission standards at copper and lead smelters.

Scrap supplies are a ready extra source of selenium in case of a significant price rise. Rectifier and xerographic scrap are two components of scrap stocks which have accumulated in the western world.

New, large scale uses for selenium in the long term are not predictable. Indeed while existing uses are unlikely to be threatened by substitution at existing prices in the medium term, technological advances such as new photocopying processes or the use of alternative photoreceptors have the potential to seriously reduce consumption. Such technical advances, like new large-scale uses, are difficult to predict.

The introduction of a major new use would be inhibited by the constraint upon supplies, as primary selenium production is a function of copper production. Although selenium recoveries could be improved and significant supplies of inventoried scrap could be processed to meet the increased demand, ultimately supply is constrained.

Given significant sustained new demand, prices would rise, encouraging the use of substitute materials.

Health-related uses are likely to increase. Selenium is now added to vitamin tablets for humans, and to animal and poultry feeds. Selenium has also been studied as a dietary cancer preventative agent.

Prices for commercial grade material are likely to remain in the range of US$6-10/lb. in 1988 but could rise above $10/lb. in the short term. Significant price rises will likely be inhibited by the stocks of scrap selenium and also by the marketing strategies of producers. Prices of $10 are thought to be insufficient to evoke reprocessing of the majority of existing scrap stocks. Much of the existing scrap inventories require a price of $12-15 before reprocessing can be profitable. The long term interests of major producers and consumers might not be best served by large-scale price increases which encourage substitution away from selenium.

TELLURIUM

Tellurium, like selenium, is recovered in Canada from the tankhouse slimes at electrolytic copper refineries. It is refined by the same two companies which refine selenium: Noranda Inc.'s CCR Division at Montreal East, Quebec, and INCO Limited at Copper Cliff (Sudbury), Ontario. Although more "metallic" than selenium, tellurium resembles selenium and sulphur in its chemical properties and, like selenium, is a semiconductor. Tellurium output is related to selenium output because tellurium is a coproduct of selenium recovery.

CANADIAN DEVELOPMENTS

Production of primary recoverable tellurium in Canada was 17.6 t in 1986, is estimated at 15 t in 1987 and is forecast at 16 t for 1988. The strike at Noranda's Horne smelter from November 1986 to February 1987 reduced production (Table 4). The large difference between production (all forms) and refined production in some years is attributable to market conditions. Producers refine according to sales and can stockpile any surplus in less processed forms.

CCR Division has a capacity of up to 27.2 t/y of primary and secondary tellurium in powder, stick, lump and dioxide forms.

The Copper Cliff refinery has a capacity of up to 8.2 t/y of tellurium in the form of dioxide (77% Te).

In 1982, Cominco Ltd. built a $3 million plant at Trail, British Columbia to expand its production of mercury-cadmium telluride (MCT) in the form of single crystals. When sliced into thin wafers and polished, this compound is used in a wide range of electronic devices that detect infrared radiation to provide optical images or data. This plant is the only non-captive producer of such crystals and is the largest producer of high-purity detector grade tellurium.

WORLD DEVELOPMENTS

Detailed information about world tellurium production is unavailable. Information from Australia, U.S.S.R., Federal Republic of Germany, the United States, Chile, Zaire and Zambia is either unavailable or insufficient to allow estimation. In the United States, the sole producer is ASARCO Incorporated. In the Mining Annual Review, 1986 western world production and consumption were estimated at 161 t and 188 t respectively. Demand data in the United States is withheld. Sumitomo Metal Mining Co. Ltd. is building a plant to produce 50 kg/month of 99.99999% Te metal. Its existing pilot plant has a capacity of 10 kg/month.

PRICES

Most of the commercial-grade tellurium sold by the primary producers is in the form of slab, stick, lump, tablet or powder. It is also sold in the form of copper-tellurium and iron-tellurium alloys. Normal commercial grades contain a minimum of 99% or 99.5% tellurium. Tellurium dioxide is sold in the form of minus 40 to minus 200-mesh powder containing a minimum of 75% tellurium.

As a result of falling prices, producers suspended publication of tellurium prices on January 5, 1981. Prices in 1986 are believed to have ranged between US$8.50 and $14/lb., depending upon lot size, frequency of purchases and market conditions.

USES

Over exposure to tellurium could be hazardous to health, but fortunately tellurium imparts a disagreeable odor at low concentrations and this early warning signal has prevented any recorded toxic industrial exposures. Major uses are as additions to ferrous and nonferrous alloys to improve machineability or otherwise improve their metallurgical properties, but bismuth is increasingly being used as a substitute. Tellurium also performs an important role in the manufacture of rubber products, thermoelectric devices, catalysts, electronics, insecticides and germicides, delay blasting caps, glass, ceramics and pigments.

The demand for tellurium in the United States by end-use in 1983 was estimated by the U.S. Bureau of Mines as: iron and steel products, 65%; nonferrous metals, 17%; chemicals including rubber manufacturing, 8%; other, including xerographic and electronic applications, 10%. The 1985 distribution pattern is estimated to be similar to that of 1983.

OUTLOOK

The supply of tellurium is a function of copper output and the recovery rate from the feed material. Present prices do not generally justify expenditures to increase recovery rates. In the short to medium term, demand is expected to grow slowly and supply should be adequate to meet requirements. However, as new copper production is increasingly derived from tellurium-poor ores, the total available supply of tellurium is even more limited than that of selenium. Application of significant new uses of tellurium, such as in solar collectors, or in the form of mercury-cadmium telluride in photovoltaic cells, would increase demand, thereby causing the higher prices that would justify a higher recovery from tellurium-bearing copper ores. Military and aerospace applications have the potential to increase MCT demand, presumably even if prices were to rise significantly.

TABLE 1. CANADA, SELENIUM EXPORTS 1985-87

	1985		1986		Jan.-Sept. 1987	
	(tonnes)	($)	(tonnes)	($)	(tonnes)	($)
Exports						
United States	125	3 224 868	133	3 341 918	86	2 376 051
United Kingdom	66	1 304 134	83	1 416 367	54	897 438
Netherlands	46	990 441	52	769 618	26	388 574
People's Republic of China	26	547 050	2	34 130	5	90 968
Belgium and Luxembourg	29	695 924	28	407 339	5	88 888
Philippines	0	0	0	0	2	61 681
India	...	52 565	1	58 775	...	31 053
West Germany	0	0	...	3 329	3	21 700
France	0	0	...	1 345	...	19 995
Argentina	...	9 493	1	27 889	1	17 742
Puerto Rico	4	325 723	5	350 724	...	9 971
Mexico	0	0	0	0	...	4 575
Colombia	...	1 647	0	0	0	0
Barbados	0	0	2	922	0	0
Chile	0	15 959	0	0	0	0
Japan	2	138 730	2	149 295	0	0
Spain	11	252 227	39	607 272	0	0
New Zealand	0	0	...	5 936	0	0
Thailand	...	9 576	0	0	0	0
Total	309	7 568 337	348	7 174 859	182	4 008 636

Sources: Energy, Mines and Resources Canada; Statistics Canada.
... Amount too small to be expressed.
Note: 1983 Canadian exports incorrectly showed exports of 453 t to Belgium: the actual exports were 1 t to Belgium, with total Canadian 1983 exports of 255 t.

TABLE 2. CANADA, SELENIUM PRODUCTION, EXPORTS AND CONSUMPTION, 1970, 1975, 1980, AND 1985-88

	Production[1]	Exports[2]	Consumption[3]
		(tonnes)	
1970	388	311	7.1[3]
1975	342	218	9.9[3]
1980	377	307	10.8[3]
1985	360	309	13.9[4]
1986	345	348	14.0[4]
1987[e]	345	182[5]	..
1988[f]	355	..	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Until 1985, refinery output of selenium from all sources, including imported concentrates, blister and scrap and domestic scrap; from 1986 onwards, primary recoverable output. [2] Exports of selenium, metal powder, shot, etc. [3] Consumption (selenium content) as reported by consumers. [4] Consumption (selenium content) as estimated by Noranda Inc. [5] Jan.-Sept.

[e] Estimated; [f] Forecast; .. Not available.

TABLE 4. CANADA, PRODUCTION AND CONSUMPTION OF TELLURIUM, 1970, 1975, 1980 AND 1985-88

	Production[1]	Consumption Refined[2]
	(tonnes)	
1970	29	0.4
1975	42	w
1980	9	w
1985	19	..
1986	17	..
1987[e]	15	..
1988[f]	16	..

[1] Refinery output of tellurium from all sources, including imported concentrates, blister, and scrap and domestic scrap, to 1985. For 1986 onward, primary recoverable output. [2] Consumption (tellurium content), as reported by consumers.

w Withheld to avoid disclosing company data; .. Not available; [e] Estimated; [f] Forecast.

TABLE 3. EUROPEAN FREE MARKET SELENIUM PRICES, MINIMUM 99.5%, IN WAREHOUSES

	(US$/lb.)			
	1986		1987	
	low	high	low	high
January	6.83	7.04	4.79	5.20
February	6.61	6.79	4.33	4.98
March	6.34	6.49	4.33	4.97
April	5.96	6.23	4.74	5.22
May	5.43	5.81	5.09	5.53
June	4.43	4.87	5.48	6.13
July	3.93	4.23	5.37	5.98
August	4.93	5.13	5.41	5.94
September	5.16	5.36	5.66	5.99
October	5.23	5.59	6.19	6.42
November	5.11	5.44	6.71	6.88
December	4.84	5.15	8.35	8.69
Average	5.40	5.68	5.55	6.01

Source: Metals Bulletin.

These prices reflect known transaction prices that constitute only a small proportion of selenium sales. Prices realized by producers are not reported, but are thought to have ranged from US$5.00 to $7.50/lb. for commercial grade material in 1986, and from US$13 to $18/lb. for high purity selenium.

Silica

M.A. BOUCHER

SUMMARY

Preliminary figures indicate that in 1987 silica production in Canada decreased 3% in terms of tonnage while the total value of production increased 6%. Production increased in New Brunswick, Quebec and Manitoba, decreased in Newfoundland and Ontario, and remained about the same in the rest of the country.

With the exception of the flat glass and fiberglass markets which are related to the construction industry, all the other markets for silica were either stagnant or declining in 1987.

The consumption of silica by the glass container industry which is the largest consumer of high quality silica continued to be affected negatively by the use of recycled glass waste. Competition from aluminum, paper and plastics also continued to erode markets traditionally belonging to glass containers.

CANADIAN SCENE

Newfoundland

All silica production from Dunville Mining Company Limited, a subsidiary of Tenneco Canada Inc. is captive to Tenneco, a producer of elemental phosphorus, where silica is used as a flux. The quartzite quarry at Villa Marie operates from May to December and produces silica grading close to 95% SiO_2. The ore is shipped to Tenneco's Long Harbour phosphorus plant.

Nova Scotia

Nova Scotia Sand and Gravel Limited produces a high purity silica from sand deposits, for a variety of uses such as sandblasting, glass, foundry sand, and frac sand. The mine is located near Shubenacadie.

New Brunswick

Chaleur Silica Ltd. produces silica for use as a flux in Brunswick Mining and Smelting Corporation Limited's Belledune lead smelter, for cement plants, and as sandblasting material.

Quebec

Falconbridge Limited is the largest producer (in terms of volume and value of production) of silica east of Ontario with a total production capacity of some 500 000 t/y. Silica is mined from a quartzite deposit at Saint Donat and from a sandstone deposit at Saint Canut. Silica from Saint Donat is refined at the Saint Canut plant near Montreal.

Most silica produced by Falconbridge originates from Saint Canut where the ore is crushed, screened and beneficiated by attrition scrubbing, flotation and magnetic separation. The company reported it was building a $2.5 million crusher plant at Saint Canut which will include a jaw crusher, a cone crusher and screens. Production capacity will remain the same, but the new crusher plant will be more efficient. The major markets for Falconbridge products are the glass, fiberglass and silicon carbide industries.

Uniquartz Inc. mines a silica deposit near St. Jean Vianney about 30 km from Matane.

The deposit is reported to contain 9 to 15 Mt of high purity ore. Some 90 000 t/y of ore are sold to European consumers for the production of ferro-alloys.

A concentrator is under construction for the production of higher purity silica. Eventually the company intends to produce some 300 000 t/y of high purity silica for use by the silicon metal, ferrosilicon, and glass industries.

Baskatong Quartz Inc. produces high-purity silica from a quartzite deposit north of Saint Urbain. The silica is used

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mainly by SKW Canada Inc. for the production of ferrosilicon and silicon metal. Baskatong also produces high-purity silica from quartz vein deposits located at Lac Bouchette south of Lac Saint-Jean. The silica is sold almost exclusively to SKW for the production of ferrosilicon.

Loma Entreprises Ltd. of Beauport crushes and classifies the fines produced by SKW Canada Inc. The silica is sold to the silicon carbide and sandblast industries.

Armand Sicotte & Sons Limited mines Potsdam sandstone at Sainte Clothilde, south of Montreal. Lump silica is used for the production of ferrosilicon, phosphorus, and in the cement industry.

La Compagnie Bon Sable Ltée mines silica sand and gravel at St. Joseph-du-Lac and at Ormstown. The material is used mainly for sandblasting but also for fiberglass and foundries.

Ontario

Falconbridge Limited is also the largest producer (in terms of volume and value of production) of silica west of Quebec, with a reported total capacity of about 500 000 t/y, about the same as its Quebec operation. Lump quartzite from Badgeley Island, north of Georgian Bay is shipped by lake boat to Canadian destinations for the manufacture of ferrosilicon. The finer material produced by crushing, is shipped to Midland, south of Georgian Bay where it is further processed to a glass-grade silica sand, and silica flour for ceramic and other uses.

Manitoba

Marine Transport Limited of Selkirk, produces high-purity silica sand from a quarry on Black Island on Lake Winnipeg some 130 km north of Selkirk. The silica sand, mined from a poorly consolidated white sandstone, is well rounded and suitable for use in foundries, glass and fiberglass. The ore is washed, screened and dewatered at a plant on the island, and is then shipped by barge to a processing plant at Selkirk on the Red River.

INCO Limited produces a low-grade silica from an impure quartzite from the Manasan quarry for its Thompson smelter and converter. Production varies from year to year depending on nickel production.

Saskatchewan

Hudson Bay Mining and Smelting Co., Limited (HBM&S) produces smelter flux from two pits in northern Saskatchewan.

Red Deer Silica Inc. holds a silica deposit near the town of Hudson Bay. The deposit contains more than 14 Mt proven reserves of silica grading 97 to 99% SiO_2 with trace amounts of alumina and iron oxide. The company intends to produce about 200 000 t/y of silica for the foundries, sandblasting, filtration, flux and glass industries. Financial negotiations are ongoing for a beneficiation plant to be built at Hudson Bay.

Alberta

Sil Silica, division of Strathcona Resource Industries Ltd., produces silica sand from local sand dunes in the Bruderheim area. Silica is sold mainly as fiberglass and sandblasting material. It is also sold as foundry sand, filtration sand, frac sand and as railway traction sand. Sil Silica has shown steady growth even during depressed economic conditions.

British Columbia

Mountain Minerals Co. Ltd. mines a high-purity, friable sandstone deposit near Golden. Rock is crushed, screened, washed, dried and separated into several sizes. These different sizes are sold for glass sand, sandblasting sand, foundry sand, filter media sand, golf course sand and fine sand.

TRADE

Most silica sand imported into Canada comes from loosely consolidated and easily processed sandstone or lake sand deposits located near the Great Lakes region of the United States in Illinois, Wisconsin, Michigan and Indiana. The imported silica sand is used mainly by iron and steel foundries and by the glass industry of Ontario and Quebec.

OUTLOOK

Little improvement is expected in 1988 in Canada in the container glass, foundry and sandblast industries. The flat glass and fiberglass industries should fare better as strong activity continues in the construction industry. In the long term, competition from U.S. producers of silica for glass and foundry sand will remain strong in Ontario and Quebec because of the proximity of these provinces to the low-cost producers of the United States Great Lakes region. Also due to the downsizing of passenger cars and recycling of silica sand at foundries, no growth can be expected in the foundry sand industry in Canada. Competition from substitutes for glass containers such as paper, plastics and aluminum will remain strong across Canada.

Productivity improvements and innovation such as the development of glass containers that are strong, lighter (thinner glass wall) and safer (thin glass wall covered with plastic foam) will be necessary in order to prevent a further erosion of the glass containers markets.

OPPORTUNITIES

Higher value silica products could be produced in Canada because electricity is not expensive in certain parts of the country. Such products include:

a) cultured quartz
b) raw vitreous silica (MN.99.8% SiO_2) and manufactured products of vitreous silica (two fusion of silica are necessary for example to produce tubes and rods);
c) refined silicon carbide
d) monocrystalline silicon
e) high-purity ground silica (MN.99.5% SiO_2; 2 to 20 microns).
f) silicon nitride

None of these products are yet manufactured in Canada.

Also there are potential opportunities for:

g) new flat glass plants in Canada; and
h) an integrated silicon carbide plant in western Canada, based on local raw materials and inexpensive electricity.

PRICES

The unit value of shipments of silica in Canada was $17.30 a tonne in 1987. This compares with $15.77 in 1986.

TABLE 1. CANADA, SILICA PRODUCTION (SHIPMENTS) AND TRADE, 1985-87

	1985		1986		1987P	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Production (shipments), quartz and silica sand						
By province						
Quebec	741 617	15 428	836 580	17 025	850 000	18 162
Ontario	1 126 358	11 499	1 029 506	10 716	925 759	10 627
Alberta	x	4 432	x	3 355	x	4 300
Manitoba	x	2 808	x	2 872	x	3 015
Nova Scotia	x	x	x	x	x	x
New Brunswick	x	x	x	x	x	x
Saskatchewan	147 916	x	128 400	x	133 631	x
Newfoundland	x	1 584	x	1 526	x	1 150
British Columbia	x	2 180	x	1 896	x	2 308
Total	2 668 650	42 536	2 640 436	41 640	2 560 411	44 308
Imports[1]					(Jan.-Sept. 1987)	
Silica sand						
United States	983 315	22 708	1 055 209	20 200	574 315	11 245
West Germany	8	1	6	-	60	10
Other countries	17	5	-	-	-	-
Total	983 340	22 714	1 055 215	20 200	547 375	11 255
Silex and crystallized quartz						
United States	312	289	318	270	272	253
Japan	12	18	30	44	-	-
Other countries	17	19	1	2	5	7
Total	341	326	349	316	277	260
Silica (incl. silica gel)						
United States	7 207	12 493	8 742	13 515	6 932	11 192
West Germany	1 018	2 425	1 049	3 142	489	1 911
Other countries	723	1 366	565	1 143	379	719
Total	8 948	16 284	10 356	17 800	7 800	13 822
Exports						
Quartzite						
United States	112 762	1 136	88 393	1 143	45 432	625
Other countries	-	-	-	-	-	-
Total	112 762	1 136	88 393	1 143	45 432	625

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Includes sand for use in foundries and glass manufacturing, ground and flour sand, volatized and silica flue dust.

P Preliminary; - Nil; x Confidential.

TABLE 2. IMPORTS OF SILICA SAND, (FROM UNITED STATES) BY PROVINCE BY USE, 1986

Use	Unit	Newfoundland	Nova Scotia	Prince Edward Island	New Brunswick	Quebec	Ontario	Manitoba	Saskatchewan	Alberta	British Columbia	Total
Foundry	tonnes	91	1 627	-	235	30 899	445 493	318	113	1 059	31 329	511 165
	$000	1	29	-	9	1 043	5 184	17	12	24	1 219	7 539
Glass manufacturing	tonnes	-	-	-	-	867	263 091	-	-	-	2 136	266 095
	$000	-	-	-	-	25	3 109	-	-	-	75	3 210

Source: Statistics Canada.
- Nil.

TABLE 3. CANADA, SILICA PRODUCTION TRADE AND CONSUMPTION, 1970, 1975, AND 1980-86

Year	Production Quartz and Silica Sand	Imports Silica Sand	Imports Silex or Crystallized Quartz	Exports Quartzite	Consumption[1] Quartz and Silica Sand
	(tonnes)				
1970	2 937 498	1 176 199	186	58 917	3 979 305
1975	2 491 715	1 044 160	1 550	39 977	3 510 818
1980	2 252 000	1 200 237	281	63 166	3 326 956
1981	2 238 000	1 142 880	251	119 347	3 079 225
1982	1 797 000	788 768	241	65 333	2 400 549
1983	2 303 451	982 662	271	103 960	2 792 580
1984	2 658 932	1 076 082	494	116 283	3 145 308r
1985	2 668 650	983 271	341	112 762	3 109 667
1986	2 640 436	1 055 215	349	88 393	2 954 085

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Available data, as reported by consumers.
r Revised.

TABLE 4. TYPICAL BATCH FORMULATIONS FOR FLAT GLASS AND GLASS CONTAINERS

Raw Materials	% by Weight	Source of
Flat glass[1]:		
Silica sand	60	SiO_2
High calcium Limestone	4	CaO
Dolomitic Limestone	15	MgO & CaO
Soda ash	20	Na_2O
Salt cake or gypsum	0.5	Na_2O/CaO & SO_3
Rouge	0.5	Fe Colorant
Glass containers[2]:		
Silica sand	60	SiO_2
Limestone	14-18	CaO,MgO
Soda ash	19	Na_2O
Alumina source (feldspar, nepheline syenite or aplite)	4-5	Al_2O_3,Na_2O,SiO_2
Others		
Gypsum and/or barite	1	SO_3/BaO

Sources: [1] LOF Glass Company, Toledo, Ohio. [2] Brockway, Inc., Brockway, Pennsylvania.

TABLE 5. FLAT GLASS AND CONTAINER GLASS MANUFACTURING PLANTS IN CANADA

Company	Plant Location	Type of Glass
PPG Canada Inc.	Owen Sound, Ontario	Flat
Ford Glass Limited	Scarborough, Ontario	Flat
Domglas Inc.	Scoudouc, N.B.	Containers
	Montreal, Quebec	"
	Brampton, Ontario	"
	Hamilton, Ontario	"
	Redcliff, Alberta	"
Consumers Packaging Inc.	Montreal, Quebec	Containers
	Candiac, Quebec	"
	Toronto, Ontario	"
	Milton, Ontario	"
	Lavington, B.C.	"

TABLE 6. CANADA, REPORTED CONSUMPTION OF SILICA, BY INDUSTRIES, 1985 and 1986

	1985	1986P
	(tonnes)	
Primary glass and containers, and glass fibre wool	834 579	904 761
Smelter flux	1 070 409	801 600
Foundries	438 648	392 949
Cement and concrete products	178 531	231 858
Chemicals	198 495	215 766
Structural clay products	165 645	165 976
Artifical abrasives	105 872	119 366
Other products[1]	119 179	121 809
	3 109 667	2 954 085

[1] Includes asbestos products, asphalt roofing products, ceramic products, cleansers, fertilizers, frits and enamels, paint and varnish, pulp and paper products, refractory brick, rubber products, ferro-alloys, primary steel and other miscellaneous products.
P Preliminary.

Silver

D. LAW-WEST

Silver prices reversed a four year trend and increased 28% in 1987 to average US$7.02, compared with $5.47 the previous year. The increase reflected the general strengthening trend in metal prices during the year, as well as the impact of market speculators.

CANADIAN DEVELOPMENTS

Canadian silver production increased by 15% to 1 250 t in 1987, mainly on the strength of higher base metals production.

In New Brunswick, silver production increased by nearly 30%, to over 200 t, mainly as the result of higher production at Brunswick Mining and Smelting Corporation Limited's operations at Bathurst.

Quebec almost doubled its silver output to over 120 t during the year. Les Mines Selbaie's expanded base metal mining operation accounted for the largest part of the increase. Additional increases in silver output were also reported by some of the smaller precious-base metal mines.

Ontario's silver production appears to have dropped marginally during the year, to about 336 t from 347 t in 1986. Reduced recovery from base metal mining operations more than offset increased production from the silver operations of Agnico-Eagle Mines Limited where the rebuilt Penna mill, destroyed by a fire in 1986, resumed operation early in 1987. A new silver producer, the Silverside Resources Inc. - International Platinum Corporation project near Cobalt, is expected to begin producing about 90 kg/d of silver, early in 1988.

Silver production in the prairie provinces remained unchanged during the year, totalling nearly 40 t, but is expected to increase in the near future when several new precious metals producers come on-stream.

British Columbia reported an increase of nearly 20 t, some of which was recovered by the two newest precious metal mines, the Nickel Plate owned by Mascot Gold Mines Limited and Blackdome owned by Blackdome Mining Corporation.

The Yukon also had a large increase in silver production of just over 40% to 133 t in 1987. The largest increase was reported by Curragh Resources Corporation at its Faro operation. The Mount Skukum mine, in its first full year of production, also accounted for some of the increase. Silver production in the Northwest Territories continued to fall in 1987.

WORLD DEVELOPMENTS

World silver production rose by about 5% to around 1 250 t in 1987. The United States, where several large producers had suspended production due to low prices in 1986 and opened in 1987, accounted for over half of the increase.

Peru, one of the largest producers, attempted to stabilize silver prices in late April by suspending foreign sales. Silver prices had just reached a four year high of over US$8.00 and within a few weeks hit a spot price of $11.25. The sales ban was still in place at year-end but prices had fallen to below $7.00 because only a small portion of actual production was affected.

Mexico, also a major silver producer, introduced silver-backed certificates in an effort to increase the demand and perhaps the price for silver.

CONSUMPTION AND USES

Silver consumption increased for the third consecutive year to 13 240 t in 1986 from 12 215 t in 1985 but was still far below the peak of 16 065 t in 1973.

The photographic sector remained the largest user of silver, accounting for over 40% of consumption in 1986. Photography can be subdivided into smaller categories,

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namely x-rays (38%), conventional photography (30%), graphic arts (20%) and other applications such as motion picture films and instant films (12%). This sector, in addition to being the largest consumer, is also a leader in innovative technologies aimed at reducing its silver consumption. Recent developments have reduced the amount of silver required per exposure, introduced new and more efficient materials management systems which have reduced silver loses during processing, and increased silver recycling.

Electronic imaging, using no silver, is seen as having the largest long term effect on silver consumption. While video recorders and video-still recorders are already available on the market, their high prices have kept them beyond the reach of the average household. Some analysts see electronic imaging accounting for at least 50% of the traditional photographic market, by the end of this century.

Silver used in the electrical and electronic industries accounts for about 30% of consumption. Its high electrical conductivity as well as its resistance to oxidation makes silver the preferred material for contact points in switches. Several important alloys including silver/copper, silver/cadmium, and silver/refractory metal alloys find a variety of uses in high current and voltage environments. Miniaturization in the electronics industry has reduced silver consumption per unit but this has been offset by the industry's rapid expansion. In addition, the smaller amounts of silver have reduced the economics of recovering silver from used parts.

The jewellery and sterlingware markets have declined significantly over the past few years. Silver consumption in these end-uses has declined to less than 5% of the total from over 20% a decade ago. This is one area where consumption could be increased using a strong and well planned promotional campaign supported by both the producing and consuming sectors.

Silver used in coins increased dramatically in 1986 when both the United States and Japan introduced silver bullion coins in parallel with their gold bullion coins. The silver eagle coin introduced in October used more than 150 t. This, combined with the 200 t of silver used for the Hirohito coin and the 155 t for the Canadian Olympic coin program brought total coinage use of silver to over 500 t. While the Japanese and Olympic coin programs are both short term in nature, continuing sales of the U.S. coin are expected to partly compensate in 1988 and beyond.

Other industrial uses of silver include catalysts for chemical processing, mirrors, brazing and soldering alloys, electroplating, dental amalgams, medical equipment, chemicals, medallions and commemorative objects.

OUTLOOK

Silver remains in limbo, caught between being an industrial metal with a price that reflects supply and demand conditions, and an investment metal with a price that reflects economic and political conditions.

Large stocks of the metal still overhang the market and coupled with the fact that over 70% of silver production has an industrial application, silver prices should remain in the $6.00-8.00 range in the next year. Notwithstanding the above, there is a high probability that the price may vary on either side of the range.

TABLE 1. CANADA, SILVER PRODUCTION AND TRADE, 1985-87

	1985		1986		1987P	
	(kilograms)		(kilograms)		(kilograms)	
Production[1]						
By province and territories						
Newfoundland	-		-		50	
New Brunswick	175 419		162 869		208 200	
Nova Scotia	-		-		4	
Quebec	61 436		62 232		123 260	
Ontario	455 644		347 624		336 000	
Manitoba	40 179		37 416		37 700	
Saskatchewan	5 581		3 145		1 600	
Alberta	-		2		1	
British Columbia	379 277		379 966		397 338	
Yukon Territories	46 966		73 061		132 900	
Northwest Territories	32 570		21 674		12 800	
Total	1 197 072		1 087 989		1 249 853	
Total Value (C$000)	333 839		275 011		373 681	
Imports	(kilograms)	($000)	(kilograms)	($000)	(kilograms)	($000)
Silver in ores and concentrates					(Jan.-Sept.)	
United States	11 572	2 700	14 186	3 411	2 348	691
Italy	-	-	-	-	21 662	4 505
Peru	53 048	11 467	74 096	13 329	46 423	8 931
Mexico	-	-	-	-	7 898	1 791
Chile	9 569	2 279	5 745	1 185	11 637	3 073
Bolivia	3 687	816	5 282	1 020	1 460	251
Other	22 640	4 311	18 887	3 233	0	0
Total	100 516	21 573	118 196	22 178	91 428	19 242
Refined metal						
United States	540 052	146 443	156 882	35 808	95 687	26 492
West Germany	8 627	2 128	3 071	592	1 138	189
Puero Rico	-	-	678	369	298	169
United Kingdom	986	54	1 325	73	1 560	37
Other	26 150	8 901	4 806	1 186	566	148
Total	575 815	157 526	166 762	38 028	99 249	27 035
Exports						
Silver in ores and concentrates						
Japan	242 600	48 887	247 892	45 072	221 942	45 991
Belgium-Luxembourg	9 667	1 893	19 602	2 269	29 137	7 582
West Germany	16 348	1 728	4 480	429	21 907	3 851
Finland	933	46	-	-	14 898	2 607
United States	32 026	5 032	42 104	7 868	16 857	2 511
Italy	10 458	1 001	10 124	1 052	9 949	1 923
People's Republic of China	3 859	1 004	7 644	1 525	8 040	1 639
Australia	-	-	5 301	674	9 926	1 439
United Kingdom	8 969	789	8 603	715	9 338	1 169
Other	13 974	2 572	25 233	3 943	14 387	2 478
Total	338 834	62 954	370 983	63 547	356 381	71 190
Refined metal						
United States	1 324 540	360 324	1 308 368	321 772	221 942	111 695
Mexico	-	-	-	-	29 167	424
West Germany	72	22	197	56	21 907	127
Belgium-Luxembourg	171	46	150	37	14 898	112
Chile	224	93	45	15	16 857	15
Other	687	224	2 921	665	77 702	24
Total	1 325 694	360 709	1 311 681	322 545	382 473	112 397

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Includes recoverable silver in: ores, concentrates and matte shipped for export; crude gold bullion produced; blister and anode copper produced at Canadian smelters; and base and other bullion produced from domestic ores.

P Preliminary; - Nil.

TABLE 2. CANADA, SILVER PRODUCTION, TRADE AND CONSUMPTION, 1975, 1980-87

	Production[1]	Exports			Imports, Refined Silver	Consumption[2] Refined Silver
		In Ores and Concentrates	Refined Silver	Total		
			(kilograms)			
1975	1 234 642	471 410	713 566	1 184 976	420 078	642 089
1980	1 070 000	396 690	881 761	1 278 451	339 180	265 938
1981	1 129 394	546 449	914 800	1 461 249	327 328	292 130
1982	1 313 630	602 603	1 134 347	1 736 950	484 240	180 459
1983	1 197 031	439 406	1 045 867	1 485 273	339 439	283 349
1984	1 326 720	423 963	1 081 391	1 505 354	215 192	299 440
1985	1 197 072	331 339	1 324 995	1 656 334	575 815	320 000
1986	1 087 989	370 983	1 311 681	1 682 664	166 762	400 000
1987P	1 249 853	356 381[3]	382 473[3]	738 854[3]	99 249[3]	650 000

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Includes recoverable silver in: ores, concentrates and matte shipped for export; crude gold bullion produced; blister and anode copper produced at Canadian smelters; and base and other bullion produced from domestic ores. [2] In some years includes only partial consumption for coinage. [3] Exports and imports are Jan.-Sept. figures.
P Preliminary.

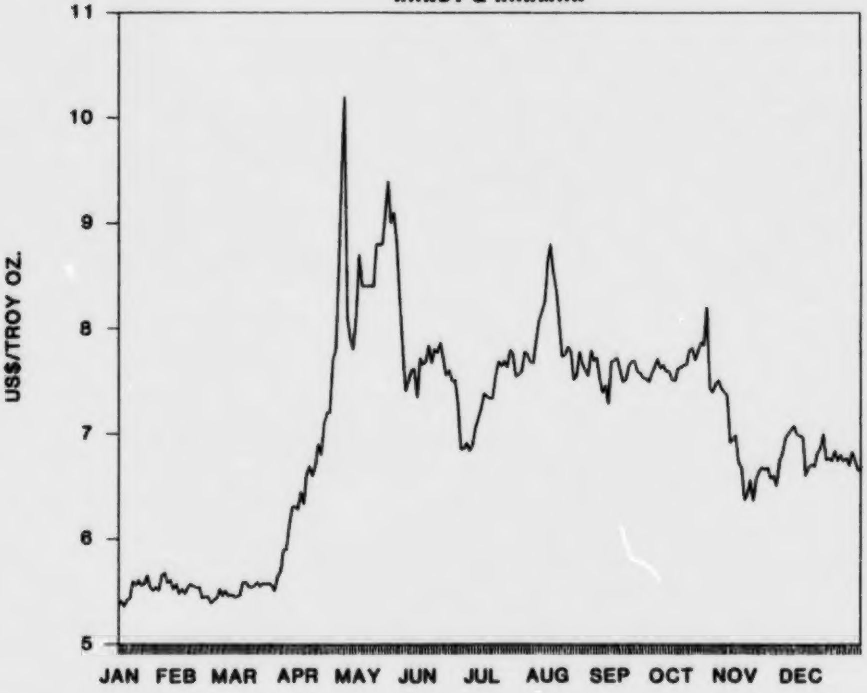
TABLE 3. SILVER MINE PRODUCTION IN THE NON-COMMUNIST WORLD, 1982-87

	1982	1983	1984	1985	1986	1987P
				(tonnes)		
Latin America						
Mexico	1 841	1 978	1 987	2 153	2 196	2 250
Peru	1 691	1 728	1 663	1 770	1 742	1 865
Chile	382	468	487	518	487	380
Brazil	53	55	67	67	66	66
Bolivia	173	187	142	111	83	88
Other	225	201	209	202	189	160
Total Latin America	4 365	4 617	4 555	4 821	4 763	4 809
Canada	1 314	1 197	1 171	1 197	1 087	1 250
United States	1 252	1 350	1 382	1 205	980	1 250
Europe	626	726	752	784	805	815
Africa						
South Africa	216	203	218	209	230	230
Morocco	101	119	127	139	139	165
Namibia	88	110	106	106	106	110
Other	119	104	96	76	78	78
Total Africa	524	536	547	530	553	583
Asia						
Japan	306	307	324	340	340	340
Philippines	64	59	50	54	52	54
South Korea	2	45	67	70	70	70
Other	147	124	143	127	137	136
Total Asia	519	535	584	591	599	600
Oceania						
Australia	907	1 033	1 063	1 063	1 055	1 047
Other	44	48	45	47	57	60
Total Oceania	951	1 081	1 108	1 110	1 112	1 107
Total	9 551	10 042	10 099	10 238	9 899	10 414

Source: Shearson Lehman Brothers, Annual Silver Review 1987.
P Preliminary.

DAILY SILVER PRICES 1987

HANDY & HARMAN



Sodium Sulphate

G. BARRY

Sodium sulphate is mainly produced from natural brines and deposits in alkaline lakes in areas with dry climates and restricted drainage, from subsurface deposits and brines, or as a by-product of chemical processes. Canada's sodium sulphate industry is based on extraction from natural brines and deposits in several alkaline lakes in Saskatchewan and Alberta. Seven plants producing natural sodium sulphate operated in Canada in 1986. By-product sodium sulphate is recovered at one rayon plant and at three paper mills in Ontario.

World production in 1987 was estimated at approximately 4 Mt, split about 45% between natural sources and 55% from various manufacturing processes, mainly as a by-product of viscose rayon production, hydrochloric acid, sodium dichromate and about six other chemical processes.

In the United States, natural and by-product sodium sulphate production is almost evenly split. In Europe, sodium sulphate is produced almost entirely as a by-product of chemical processes.

PRODUCTION AND DEVELOPMENTS IN CANADA

Demand for Canadian natural sodium sulphate fell principally as a result of a decline in exports to the United States. The Saskatchewan and Alberta producers responded by reducing production levels and trimming employment. Production in 1987 was reported on a preliminary basis as 340 183 t but this estimate may be too high by up to 15 000 t. The average unit value of shipments declined from $89.05 in 1986 to $76.55 in 1987. There was a shift in sales volume to the lower priced salt cake which would accentuate the decline in unit value. The average price for sodium sulphate only declined by $8 to $9/t. Exports to the United States dropped by 34.2% for the first nine months of 1987 compared to the same period last year.

Besides natural sodium sulphate, about 80 000 t/y are produced as a by-product of industrial and chemical processes in central Canada. Between 35 and 40% of the total amount of sodium sulphate produced in Canada is the higher-grade and higher-priced "detergent-grade".

Potash Corporation of Saskatchewan (PCS) completed the construction of a $10 million potassium sulphate demonstration plant at its Cory potash mine near Saskatoon. The plant has a designed capacity of 30 000 t/y. The production of potassium sulphate is achieved through a reaction of sodium sulphate with potassium chloride (glaserite process). Glaserite is trucked directly from one of the sodium sulphate producers. In 1987, capacity utilization was over 75%. The plant follows the 10 days on, 4 days off schedule as adopted intentionally for the potash mine. Commercial shipments of potassium sulphate on a continuous basis started in mid-1986.

In July of 1987, PCS completed the construction of a 10 t/d plant for the production of industrial grade potassium sulphate at Big Quill Lakes. The plant uses the ion exchange process to produce a very pure, fine grainy industrial product to a specification of 99.7% K_2SO_4. The company completed a feasibility study on a large potassium sulphate plant based on sulphate brines of Big Quill Lakes. Depending on technical and market factors, such a plant could have a capacity of up to 300 000 t/y of product and would cost somewhat less than $100 million. A decision on whether to proceed with a plant of this size has not yet been made.

In January 1985, Alberta Sulphate Limited, then entirely owned by Agassiz Resources Ltd., bought the Francana operations from Hudson Bay Mining and Smelting Co., Limited. The two deposits in Saskatchewan (Snakehole and Alsask Lakes) and the deposit in Alberta (Metiskow Lake) are now all operated under the name: Francana Minerals Inc. a division of Agassiz Resources Ltd.

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Deposits. The sodium sulphate deposits in Saskatchewan and Alberta have formed in shallow, undrained lakes and ponds where inflow is greater than outflow. Percolating ground waters carry dissolved salts into the basins from the surrounding soils. High rates of summer evaporation concentrate the brine to near saturation, and cooler fall temperatures cause crystallization and precipitation of sodium sulphate as mirabilite ($Na_2SO_4.10H_2O$). The cycle has been repeated year after year and thick deposits of hydrous sodium sulphate, accompanied by other salts and mud, have accumulated.

Identified deposits in Saskatchewan contain, in total, approximately 90 Mt of anhydrous sodium sulphate. Of this amount, a total of about 51 Mt is in 21 individual deposits, each containing more than 500 000 t of sodium sulphate. Exploitation currently takes place on the following lakes (with reserves, in millions of t, in brackets): Whiteshore Lake (6.0), Horseshoe Lake (2.7), Chaplin Lake (2.4), Ingebrigt Lake (8.1), Alsask Lake (2.0), East Coteau Lake (3.4), and Snakehole Lake and Verlo Lake (1.2), all in Saskatchewan. Production in Alberta is from Metiskow Lake (0.9).

Recovery and processing. Because most of the sodium sulphate is recovered by evaporation of concentrated brines or by dredging of the permanent beds of crystals, weather is as important for recovery of sodium sulphate as it is for its deposition. A large supply of fresh water is also essential. One method of sodium sulphate recovery is to pump lake brines that have been concentrated by hot summer weather into evaporating ponds or reservoirs. Continued evaporation produces a saturated or near-saturated solution of mirabilite. Differential crystallization occurs in the fall when the solution cools. Hydrous sodium sulphate crystallizes and precipitates, whereas sodium chloride, magnesium sulphate and other constituents remain in solution. Before freezing weather sets in, the impure solution remaining in the reservoir is drained or pumped back into the source lake. After the crystal bed has become frozen, harvesting is carried out using conventional earthmoving equipment. The harvested crystal is stockpiled adjacent to the plant.

Some operators used floating dredges to mine the permanent crystal bed. The slurry of crystal and brine is transported to a screening house at the plant by pipeline. If sufficiently concentrated, the brine from the screens is collected in an evaporation pond.

Since 1984, one company uses solution mining in lake beds that are 3 to 11 m thick. It pumps a concentrated brine to an air-cooled crystalliser at the plant where sodium sulphate is separated from other more soluble salts.

Processing of the natural salt consists of dehydration (Glauber's salt contains 55.9% water of crystallization) and drying. Commercial processes used in Saskatchewan include Holland evaporators, gas-fired rotary kilns, submerged combustion and multiple effect evaporators. Subsequent crushing and screening results in a product with uniform grain size and good flow characteristics. Salt cake, the product used principally in the pulp and paper industry, contains a minimum of 97% Na_2SO_4. Detergent-grade material analyzes up to 99.7% Na_2SO_4. Uniform grain size and free-flow characteristics are important in material handling and use.

Of the seven plants in the Prairies, four are capable of producing detergent-grade sodium sulphate. Three plants have the capacity to produce 80% or more of their output as a high-grade product. The natural sodium sulphate industry employed about 240 persons in 1987, compared to about 300 in 1986.

By-product recovery. In 1987, Courtaulds (Canada) Inc. produced approximately 20 000 t of detergent-grade sodium sulphate as a by-product of viscose rayon production at its Cornwall, Ontario plant. Maximum capacity at the Cornwall plant would be in the order of 24 000 t/y.

Ontario Paper Company Limited at Thorold, Ontario produced approximately 67 000 t of salt cake in 1987 as a by-product of paper manufacturing. The plant was closed on December 18, 1987. There is a possibility that it will be re-opened in April 1988.

PRICES

Canadian list prices of natural sodium sulphate f.o.b. western plants were approximately $79 and $100/t respectively for salt cake and detergent-grade in 1987. However, in practice, much lower prices were realized throughout the year. A $4/t price increase for the U.S. market was to be announced by some producers at the beginning of 1988. Prices for detergent-grade by-product sodium sulphate in Ontario were in the order of $160 to $170/t in bulk shipment. Freight costs for natural sodium sulphate delivered to Ontario from western Canada were over $75/t.

USES

The main end-uses for sodium sulphate are in the pulp and paper, detergent, glass and dyeing industries.

In the chemical pulping of wood, the digestion reagents consist of about two-thirds caustic soda and one-third sodium sulphide obtained by using sodium sulphate as make-up. About 33% of sulphur input is retained in the organic chemicals recycled in the process. Lately, technical improvements in the process significantly reduced the consumption of sodium sulphate per t of pulp produced, to 20 kg/t or less. More caustic soda and emulsified sulphur is being substituted for salt cake. Partial substitution reduces the emission of sulphur, thus facilitating compliance with stricter environmental controls.

Sodium sulphate is used as a builder, or more correctly as a diluent in detergents (supplies "bulk"); it is claimed to improve detergency through its effect on the colloidal properties of the cleaning system. The curtailment in the usage of phosphates on grounds of pollution control necessitated added substitution of phosphates by sodium sulphate. The average sodium sulphate content of powder detergents is now around 30%. Roskill Information Services Ltd. estimates that sodium sulphate used in detergents of all types accounted for 21% of world consumption (1983). In the United States, a recent rapid growth for liquid detergents has had a negative impact on sodium sulphate demand.

Some sodium sulphate is used by the glass industry as a source of Na_2O to speed melting and to prevent scum forming on the surface of the melt. For typical container glass, sodium sulphate used is 0.36% of the weight of the glass produced. In other glass the sodium sulphate content can be much higher. However, particularly in the manufacture of flat glass, calcium sulphate and soda ash can partially replace sodium sulphate.

Sodium sulphate is used in the textile industry in the dyeing process, particularly of wool.

Sodium sulphate is used in the manufacture of a number of chemicals such as potassium sulphate, sodium sulphide, sodium silicate, sodium hyposulphite and sodium aluminum sulphate. Sodium sulphide is quantitatively the most important and is used for de-hairing hides in the tanning process.

Other end-uses include the manufacture of viscose sponges, feed supplements, boiler feed water treatments, veterinary medicines, sulphonated oils, printing inks, the ceramic industry and the photographic industry.

Since 1981, a potential new use for sodium sulphate was in coal-fired power plants. Sodium sulphate is added to coal as a conditioner since it improves the efficiency of high-temperature electrostatic precipitators by preventing clogging by fly-ash. Only about 5 kg of sodium sulphate is used for a t of coal. However, acceptance of this usage is disappointing and only two plants in the United States are known to be using this process.

Experiments were conducted in using sodium sulphate as a heat storage medium in solar energy conservation (heating) projects. To date, usage is limited, however, and it appears that another chemical, calcium chloride hexahydrate is a better material for heat-storage cells.

In the United Kingdom, research is conducted on a scrubbing liquor using sodium sulphate to remove sulphur dioxide and nitrogen from stack gas.

OUTLOOK

On balance the natural sodium sulphate industry is expected to experience a flat growth in consumption over the next few years; some analysts expect a slight negative growth.

Canadian shipments in 1987 were marginally higher than in 1986. It appears that the substitution of sodium sulphate by caustic soda and emulsified sulphur in the North American pulp and paper industry ran its course and from 1988 onward, there is even a possibility of a very small increase in this vital market.

In the detergent industry a world wide growth of 1 and 2% is still possible, but in the United States, the rapid substitution of powder detergents by liquid detergents, which contain no sodium sulphate, may result in a slight overall decline in sodium sulphate consumption. Liquid detergents now account for 40% of the U.S. market.

The United States consumes a quarter of the world production of sodium sulphate. Consumption in the United States averaged above 1.0 Mt for the past few years but in 1987 it fell to just below 900 000 t. Canadian exports to the United States declined by some 30 000 t in 1987 and will remain below traditional levels in 1988, unless additional plant closures take place.

For the world, the medium-term forecast growth rate in demand is 0.5 to 1.0%/y.

TABLE 1. CANADA, NATURAL SODIUM SULPHATE PRODUCTION AND TRADE, 1985-87

	1985		1986		1987P	
	(tonnes)	($)	(tonnes)	($)	(tonnes)	($)
Production						
Shipments						
Saskatchewan	..	30 236 681	..	29 037 668	..	23 223 366
Alberta	..	3 634 116	..	3 973 836	..	2 816 236
Total	366 217	33 870 797	370 726	33 011 504	340 183	26 039 602
						(Jan.-Sept.)
Imports						
Total salt cake and Glauber's salt						
United Kingdom	32 828	1 843 000	16 658	1 476 911	11 278	528 809
United States	588	231 000	845	171 865	1 518	402 006
Other countries	10	27 000	48	15 882	11	5 016
Total	33 426	2 101 000	17 551	1 664 658	12 807	935 831
Exports						
Crude sodium sulphate						
United States	205 254	23 028 000	220 502	23 646 418	105 126	11 263 895
New Zealand	5 517	524 000	11 984	805 948	17 113	1 281 630
Other countries	80	13 000	904	179 535	141	33 232
Total	210 851	23 565 000	233 390	24 631 901	122 380	12 578 757

Sources: Energy, Mines and Resources Canada; Statistics Canada.
P Preliminary; .. Not available.

TABLE 2. CANADA, NATURAL SODIUM SULPHATE PLANTS, 1987

	Plant Location	Source Lake	Annual Capacity (tonnes)
Alberta			
Agassiz Resources Ltd.[1]	Metiskow	Metiskow	75 000
Saskatchewan			
Agassiz Resources Ltd.[1]	Grant	Snakehole and Verlo	63 000
Agassiz Resources Ltd.[1]	Hardene	Alsask	42 500
Millar Western Industries Ltd.	Palo	Whiteshore	109 000
Ormiston Mining and Smelting Co. Ltd.	Ormiston	Horseshoe	90 700
Saskatchewan Minerals	Chaplin	Chaplin	90 000
Saskatchewan Minerals	Fox Valley	Ingebrigt	163 000
Total			633 200

Source: Company reports.
[1] Francana Minerals Inc.

TABLE 3. CANADA, SODIUM SULPHATE PRODUCTION, TRADE AND CONSUMPTION 1970, 1975, AND 1979-87

	Production[1]	Imports[2]	Exports	Consumption[3]
	(tonnes)			
1970	445 017	26 449	108 761	291 439
1975	472 196	22 638	178 182	256 385
1979	443 279	23 156	193 268	255 059
1980	496 000	20 211	245 831	232 045
1981	535 000	24 960	284 281	216 298
1982	547 000	17 293	367 924	191 988
1983	453 939	22 479	265 752	190 625
1984	389 086	20 584	238 749	235 504
1985	366 217	33 426	210 851	241 143
1986	370 726	17 551	233 390	228 360
1987	340 183P	..	..	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Producers' shipments of crude sodium sulphate. [2] Includes Glauber's salt and crude salt cake. [3] Available data as reported by consumers.
P Preliminary. .. Not available.

TABLE 4. CANADA, AVAILABLE DATA ON SODIUM SULPHATE CONSUMPTION[1], 1984-86

	1984	1985	1986P
	(tonnes)		
Pulp and paper	192 805[3]	184 087	164 061
Cleansers	36 446	47 906	54 808
Primary glass and containers	5 688	7 655	7 471
Other products[2]	565	1 495	2 020
Total	235 504	241 143	228 360

[1] Available data, as reported by consumers.
[2] Nonferrous smelting and refining, feed industry and other minor uses.
[3] Consumption increase due to increase in number of pulp and paper companies being surveyed.
P Preliminary.

TABLE 5. WORLD, SODIUM SULPHATE PRODUCTION, 1978-86

	1978	1979	1980	1981	1982	1983	1984	1985	1986
					(000 tonnes)				
Natural									
Canada	376	443	481	535	547	454	389	366	371
Mexico	331	361	372	423	471^{r}	396^{r}	414	399	400
Spain	208	208	156	188	210	312	367	481	425
United States	549	484	529	552	400^{e}	384	395	353	359
U.S.S.R.	330	340	350	350	360	360	360	360	360
Other	147	172	152	131	122	115	132	205	200
	1 941	2 008	2 040	2 179	2 110^{e}	2 021	2 057	2 164	2 115
Manufactured	3 296	3 495	2 489	2 432	2 284^{e}	2 226	2 193	2 225	2 183
Total	5 237	5 503	4 529	4 611	4 394	4 247	4 249	4 389	4 298

Sources: Roskill Information Services Ltd. to 1983; U.S. Bureau of Mines, 1984-86; EMR for the United States 1982^{e}.
^{e} Estimated; ^{r} Revised (USBM).

TABLE 6. CANADA, RAILWAY TRAIN LOADINGS OF SODIUM SULPHATE, 1984-86

	1984	1985	1986P
		(tonnes)	
Eastern Canada[1]	56 659	40 470	46 459
Western Canada[2]	377 302	346 752	340 316
Total	433 961	387 222	386 775

Source: Statistics Canada (SC 52-211).
[1] Eastern Canada refers to provinces east of the Ontario-Manitoba border. [2] Final figure has been adjusted to reflect a recalculation of data.
P Preliminary.

Stone

O. VAGT

SUMMARY

Production of all types of stone increased in 1987 to approximately 106 Mt valued at $547 million based mainly on building construction and related activity.

Strong demand continued for dimension stone mainly to supply the popular demand for exterior and interior finish for office buildings in the United States and Canada. For example, the value of Quebec production of shaped, construction-quality granite from both domestic and imported block increased nearly six fold during the past eight years, according to the Ministère de l'Energie et des Ressources. Specific types of granite, particularly for modular panelling, have shown marked increase.

CANADIAN DEVELOPMENTS

Stone mainly as crushed material, is produced in direct response to demand from the construction industry. Although less than 1% of production in terms of volume is used as building stone, trends in exports of rough building stone as well as in the value of sales of finished stone indicate the growing importance of this sector. Since 1982 the relatively strong United States dollar has maintained competitiveness in this market for many imported materials including dimension stone finished at modern European plants. However, with established expertise and good access to domestic and imported raw material, Canadian producers have found it advantageous to install new capacity mainly using Italian technology. In Quebec, Granicor inc., associated with Olympia & York Developments Ltd. and Campolonghie, opened numerous quarries to supply high quality granite in a range of colors. Similarly, members of the Quebec Granite Producers Association have expanded operations and report substantial growth in production as well as exports of finished material to the United States. In Cornwall, Ontario, Karnuk Marble Industries Inc. opened a modern marble processing plant in 1984 and in 1987 added new equipment to cut and polish a wide variety of granite for interior and exterior applications. Canroc Manufacturing Limited Partnership, of Delta, British Columbia, continued development work on several quarries to provide additional raw material for the company's modern stone processing plant serving markets in western North America and the Pacific Rim.

Several provinces are currently assessing their building stone resources with a view to serving foreign and domestic markets for finished stone. These initiatives are often undertaken through federal-provincial Mineral Development Agreements as part of Economic and Regional Development Agreements (ERDA's). Promotional literature and various specimens of stone also make up part of these projects.

Granite, limestone, marble and sandstone are the principal rock types from which building and ornamental stone is fashioned. More than 90% is used in construction-oriented projects and less than 10% is used for monument stone and other uses. Chemical uses relate mainly to limestone and are limited to the cement, lime, glass and metal smelting industries accounting for about 4% of stone production. The remaining 2 to 3% is consumed in pulverized form as filler and extender materials, and for agricultural purposes.

Most provinces gather data relative to occurrences of stone of all types and in many cases have published this information. The federal government, through the Geological Survey of Canada, has also gathered and published a great number of geological papers pertaining to stone occurrences. Works by W.A. Parks[1] and by M.F. Goudge[2] have become classics in the fields of building stones and limestones, respectively.

Atlantic provinces

Limestone. The many occurrences of limestone in the Atlantic provinces have been systematically catalogued during the past few years[3,4,5]. Deposits of commercial importance are being worked in three of the four provinces.

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In Newfoundland limestone is available from small, impure exposures in the eastern portion of the island, from small, high-calcium deposits in the central region, and from large, high-purity, high-calcium occurrences in the west. Other than periodic operation to secure aggregate for highway work, the main exploitation is by North Star Cement Limited at Corner Brook[6]. However in 1987, The Newfoundland Resources & Mining Company Limited, owned by Explaura Holdings PLC of the United Kingdom, proceeded with plans to develop a limestone aggregate operation on the Port au Port Peninsula. The region is well known and large quantities of high-calcium limestone have been outlined in the past. Shipment of 1-2 Mt/y of aggregates are planned, mainly to markets in the United States.

In Nova Scotia limestone occurs in the central and eastern parts of the province and in New Brunswick is quarried at three locations - Brookville, Elm Tree and Havelock - for use as a crushed stone, as an aggregate, for agricultural application, for cement and lime manufacture, and for use as a flux. A current study under the federal-provincial Mineral Development Agreement will address the supply-demand situation and future requirements for limestones in New Brunswick.

Granite. Occurrences of granite in the Atlantic region have been described by Carr[7]. In Nova Scotia, a grey granite is produced from operations near Nictaux and from one quarry at Shelburne for use mainly in the monument industry. A black granite from Shelburne and a diorite from Erinville have been used for monuments and for dimension stone. Construction Aggregates Ltd., of Nova Scotia, now owned by Lone Star Industries, Inc. of Greenwich, Conn., continued providing high-quality construction aggregate essentially at tidewater from the company's Strait of Canso quarry. Sea-going barges and ships are loaded at the plant site and delivery is to aggregate-poor regions as distant as Houston, Texas.

Granite is quarried intermittently from a number of deposits in New Brunswick to obtain stone of required colour and texture for specific applications. A red, fine- to medium-grained granite is quarried near St. Stephen, and fine-grained, pink, grey and blue-grey granites are available in the Hampstead (Spoon Island) district. In the Bathurst area, a brown-to-grey, coarse-grained granite is quarried upon demand, as is a salmon-coloured, medium-grained granite near Antinouri Lake, and a black, ferro-magnesian rock in the Bocabec River area. Red granite is available in the St. George district. Manufacturers of monument stone continue to import dark, crude granite from South Africa.

In Newfoundland, there is a recognized potential for the development of labradorite deposits in the Nain River area of Labrador.

Sandstone and Slate. Island Tile & Slate Limited, after start-up in 1986, continued producing slate from a quarry at Nut Cove, near Bourgoyne's Cove, Trinity Bay, Newfoundland. Red, green and purple-coloured products are available for uses in roofing and flooring. In Nova-Scotia, medium-grained buff sandstone is quarried at Wallace, for use as heavy riprap and for dimension stone.

In New Brunswick, a red, fine- to medium-grained sandstone has been quarried in Sackville for use in construction. Deposits are exploited from time to time throughout Kent and Westmorland counties for local projects and for highway work.

Quebec

Limestone. Limestone occurs in the St. Lawrence and Ottawa River valleys and in the Eastern Townships. Limestone blocks and other shapes are produced for the construction trade in the Montreal region and at various locations throughout the province. Marble has been produced in the Eastern Townships and the Lac St-Jean areas.

Granite. Quebec, the major Canadian granite producer, accounts for up to 95% of total granite shipments for use as building stone, including other construction related and monumental/ornemental uses. Since 1979, total shipments of rough and partially finished stone have doubled and the value of construction-quality granite from domestic and imported block increased from about $11 million to more than $60 million in 1987. As a result of improved marketing and advanced processing technology, more than 25 companies now quarry granite mainly in the Rivière-à-Pierre, the Lac St-Jean and the Appalachians regions.[8]

Sandstone. Of six operations producing from sandstone resources in Quebec only one is listed as marketing flagstone and construction blocks, in Hemmingford, Huntingdon County.

Ontario

Limestone. Although limestones in Ontario range from Precambrian through Devonian, the major production comes from Ordovician, Silurian and Devonian deposits[9,10]. A major provincially-funded study beginning in 1986 is in progress to assess the limestone industries of Ontario, and to describe their overall potential based on available resources.

Recently, the well-known Adair marble (Amabel formation dolomite) provided by Arriscraft Corporation, was used for the Government of Ontario's regional court on Elgin Street in Ottawa and also for the new Canadian Chancery on Pennsylvania Avenue in Washington, D.C.

Marble. This is widely distributed over southeastern Ontario and, according to the Ontario Ministry of Natural Resources reports, underlies as much as 250 square kilometres (km^2)[11].

Steep Rock Calcite, a division of Steep Rock Resources Inc., produces medium- to high-grade calcium carbonate at Tatlock and Perth for the filler and extender markets.

Granite. Granites occur in northern, northwestern and southeastern Ontario[12,13,14]. Few deposits have been exploited for the production of building stone because the major-consuming centres are in southern and southwestern Ontario where ample, good-quality limestones and sandstones are readily available. The areas most active in granite building stone production are the Vermilion Bay area near Kenora, the River Valley area near North Bay, and the Lyndhurst-Gananoque area in southeastern Ontario.

Sandstone. Sandstone quarried near Toronto, Ottawa and Kingston has been used widely in Ontario as building stone[15]. Medina sandstones vary from grey, through buff and brown to red, and some are mottled. They are fine- to medium-grained. The Potsdam stone is medium grained; the colour ranges from grey-white through salmon-red to purple, and it can also be mottled. Current uses are as rough building stone, mill blocks from which sawn pieces are obtained, ashlar, flagstone and as a source of silica for ferrosilicon and glass.

Western provinces

Limestone. From east to west through the southern half of Manitoba rocks of Precambrian, Ordovician, Silurian, Devonian and Cretaceous ages are represented. Limestones of commercial importance occur in the three middle periods and range from magnesian limestone through dolomite to high-calcium limestones[2,16].

Tyndall Stone, a mottled dolomitic limestone often referred to as "tapestry" stone, is the best known Manitoba limestone. It is widely used as an attractive building stone, and is quarried at Garson, about 50 km northeast of Winnipeg. Limestone from Moosehorn, 160 km northwest of Winnipeg and from Mafeking, 40 km east of the Saskatchewan border and 160 km south of The Pas, is transported to Manitoba and Saskatchewan centres for use in the metallurgical, chemical, agricultural and construction industries.

The eastern ranges of the Rocky Mountains contain Cambrian to Triassic limestones. Major deposits characterized by a wide variety of types occur in Devonian and Carboniferous rocks[17]. In southwestern Alberta, high-calcium limestone is mined at Exshaw, Kananaskis and Crowsnest, chiefly for the production of cement and lime, for metallurgical and chemical uses and for use as a crushed stone. Similar uses are made of limestone quarried at Cadomin, near Jasper[6].

In British Columbia, large volumes of limestone are mined each year for cement and lime manufacture, for use by the pulp and paper industry and for various construction applications[6]. Quarries on Texada Island, British Columbia have for many years provided limestone to markets in Vancouver and in Washington state by virtue of their quality and position relative to tidewater shipping facilities. Deposits on Aristazabal Island have been developed for the export market. Other operations at Terrace, Clinton, Westwold, Popkum, Dahl Lake, Doeye River and Cobble Hill produced stone for construction and for filler use[18]. Periodically, interest is revived in the possible use of travertine from a British Columbia source.

Granite. In Manitoba, at Lac du Bonnet northeast of Winnipeg, a durable, red granite is quarried for building and monument use. Grey granite located east of Winnipeg near the Ontario border is a potential source of building stone. Approximately ten Manitoba granite occurrences were assessed recently to determine their physical and aesthetic qualities and their adaptability as a building stone. The project was initiated under a federal-provincial Mineral Development Agreement.

In British Columbia, a light-grey, to blue-grey even-grained granodiorite of medium texture is available from Nelson Island and other areas. Andesite has been quarried at Haddington Island, off the northeast coast of Vancouver Island, for use as a building stone. Canroc produced a range of products from its own coral-coloured granite and from other local and imported stone.

Sandstone. Sandstone for building and ornamental uses, quarried near Banff, Alberta is hard, fine-grained, medium-grey and is referred to as "Rundal Stone".

USES

Limestones are widely distributed in Canada and are generally available in sufficient quantity and with such chemical or physical specifications that long transportation hauls are unnecessary. Limestone products are low-priced commodities and only rarely, when a market exists for a high-quality, specialized product such as white portland cement or a high-purity extender, are they beneficiated or moved long distances. Provided the specifications are met, the nearest source is usually considered, regardless of provincial or national boundaries.

Some major uses in the chemical field are: neutralization of acid waste liquors; extraction of aluminum oxide from bauxite; manufacture of soda ash, calcium carbide, calcium nitrate and carbon dioxide; in pharmaceuticals; as a disinfectant; in the manufacture of dyes, rayons, paper, sugar and glass; and in the treatment of water. Dolomitic limestone is used in the production of magnesium chloride and other magnesium compounds.

Agricultural limestone is used to control soil acidity and to add calcium and magnesium to the soil. Limestone and lime are used as soil stabilizers, particularly on highway construction projects.

Dolomite is the source of magnesium metal produced at Haley, Ontario; the company also uses a high-calcium lime from southeastern Ontario in the production of calcium metal. Dead-burned dolomitic limestone for use as a refractory is produced at Dundas, Ontario, by Steetley Industries Limited. A magnesite deposit at Eon Mountain in British Columbia has been quarried by Baymag Mines Co Limited since 1982 to produce caustic magnesia, refractory grade MgO, and more recently, fused magnesia. Calcining is done in a refurbished kiln on the property of Canada Cement Lafarge Ltd. at Exshaw, Alberta.

As a dimension stone, granite is processed for interior and exterior floor- and wall-covering, modular block panelling and for monument stone. Uniformity of colour and texture, and durability are the main features sought. Quarrying must take into account geological and structural features as well as topography and accessibility.

OUTLOOK

Dimension stone has been the subject of periodic surges of interest in the past. Recently there has been rapid expansion in the industry, particularly by Quebec granite producers; modernization has permitted several producers across Canada to offer high-quality finished products at competitive prices. Markets for building stone continue to face competition from substitutes such as aluminum, concrete, glass and ceramics. On the other hand, use of modern gang saws for cutting thin panels for cladding to be fitted to steel or concrete construction units is expected to continue improving cost effectiveness. For aesthetic reasons, demand for natural materials, particularly granite, is expected to expand as new markets are developed. Efforts continue on behalf of the industry to illustrate to architects and developers the availability of a wide range of Canadian building stones and their adaptability in modern design.

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Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
CANADA					
29635-1	Limestone, not further processed than crushed or screened	free	free	25	free
30500-1	Flagstone, sandstone and all building stone, not hammered, sawn or chiselled	free	free	20	free
30505-1	Marble, rough, not hammered or chiselled	free	free	20	free
30510-1	Granite, rough, not hammered or chiselled	free	free	20	free
30515-1	Marble, sawn or sand rubbed, not polished	free	4.0	35	free
30520-1	Granite, sawn	free	5.5	35	free
30525-1	Paving blocks of stone	free	5.5	35	free
30530-1	Flagstone and building stone, other than marble or granite, sawn on not more than two sides	free	5.5	35	free
30605-1	Building stone, other than marble or granite, sawn on more than two sides but not sawn on more than four sides	5	5.5	10	3.5
30610-1	Building stone, other than marble or granite, planed, turned, cut or further manufactured than sawn on four sides	7.5	8.0	15	5.0
30615-1	Marble, not further manufactured than sawn, when imported by manufacturers of tombstones to be used exclusively in the manufacture of such articles, in their own factories	free	free	20	free
30700-1	Marble, n.o.p.	9.0	9.0	40	6.0
30705-1	Manufactures of marble, n.o.p.	9.0	9.0	40	free
30710-1	Granite, n.o.p.	10.2	10.2	40	6.5
30715-1	Manufactures of granite, n.o.p.	10.2	10.2	40	6.5
30800-1	Manufactures of stone, n.o.p.	12.5	12.5	35	free
30900-1	Roofing slate, per square of 100 square feet	free	free	75¢	free
30905-1	Granules, whether or not coloured or coated, for use in manufacture of roofing, including shingles and siding	free	free	25	free
UNITED STATES (MFN)					
	Granite, suitable for use as monumental, paving or building stone:				
513.71	Not pitched, not lined, not pointed, not hewn, not sawed, not dressed, not polished, and not otherwise manufactured		free		
513.74	Pitched, lined, pointed, hewn, sawed, dressed, polished, or otherwise manufactured		4.2		

TARIFFS (cont'd)

Item No.		British Preferential	Most Favoured Nation (%)	General	General Preferential
UNITED STATES (MFN) (cont'd)					
	Limestone, suitable for use as monumental, paving or building stone:				
514.21	Not hewn, not sawed, not dressed, not polished, and not otherwise manufactured, per cubic foot		free		
514.24	Hewn, sawed, dressed, polished, or otherwise manufactured		6.0		
514.51	Marble, breccia, in block, rough or squared only, per cubic foot		12.0¢		
514.57	Marble, breccia, or onyx, sawed or dressed, over 2 inches thick, per cubic foot		20.0¢		
	Stone suitable for use as monumental, paving, or building stone:				
515.51	Not hewn, not sawed, not dressed, not polished, and not otherwise manufactured, per cubic foot		free		
515.54	Hewn, sawed, dressed, polished, or otherwise manufactured, per short ton		6.0¢		

Sources: Customs Tariff, 1987, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1987), USITC Publication 1910; U.S. Federal Register, Vol. 44, No. 241.

n.o.p. Not otherwise provided for.

TABLE 1. CANADA, TOTAL PRODUCTION OF STONE, 1985-87

	1985		1986		1987P	
	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)
By province						
Newfoundland	600	3 192	476	2 712	535	2 950
Nova Scotia	4 452	23 944	4 023	21 944	4 830	26 000
New Brunswick	2 394	12 168	2 344	13 064	2 465	13 750
Quebec	31 130	148 752	36 066	172 194	37 925	189 625
Ontario	37 180	168 768	45 477	226 130	51 000	260 800
Manitoba	4 155	15 787	26 831	26 831	4 125	28 000
Alberta	225	3 116	229	1 315	260	1 475
British Columbia	6 333	30 440	23 049	23 049	4 085	23 700
Northwest Territories	163	434	484	1 416	450	1 195
Canada	86 632	406 601	97 601	488 655	105 675	547 495
By use						
Building stone						
Rough	280	10 581	..	..	..	..
Monumental and ornamental stone (n.f.)	58	6 527	..	..	..	..
Other (flagstone, curbstone, paving blocks, etc.)	25	1 337	..	..	..	..
Chemical and metallurgical						
Cement plants, Canada	8 467	23 516	..	..	..	..
Cement plants, foreign	546	1 527	..	..	..	..
Lining, open-hearth furnaces	-	-	..	..	..	..
Flux in iron and steel furnaces	1 155	4 893	..	..	..	..
Flux in nonferrous smelters	76	1 761	..	..	..	..
Glass factories	228	4 357	..	..	..	..
Lime plants, Canada	5 137	15 504	..	..	..	..
Lime kilns, foreign	288	1 159	..	..	..	..
Pulp and paper mills	192	1 408	..	..	..	..
Sugar refineries	23	261	..	..	..	..
Other chemical uses	569	4 977	..	..	..	..
Pulverized stone						
Whiting (substitute)	27	1 487	..	..	..	..
Asphalt filler	241	3 152	..	..	..	..
Dusting, coal mines	7	196	..	..	..	..
Agricultural purposes and fertilizer plants	1 219	14 735	..	..	..	..
Other uses	247	9 909	..	..	..	..
Crushed stone for						
Manufacture of artificial stone	9	203	..	..	..	..
Roofing granules	336	1 415	..	..	..	..
Poultry grit	31	822	..	..	..	..
Stucco dash	17	986	..	..	..	..
Terrazzo chips	5	124	..	..	..	..
Rock wool	-	-	..	..	..	..
Rubble and riprap	2 788	10 010	..	..	..	..
Concrete aggregate	8 793	38 446	..	..	..	..
Asphalt aggregate	6 987	30 520	..	..	..	..
Road metal	25 272	98 746	..	..	..	..
Railroad ballast	5 699	34 409	..	..	..	..
Other uses	31 514	122 654	..	..	..	..
Total	100 245	440 622	..	..	..	..

P Preliminary; .. Not available; - Nil; (n.f.) Not finished or dressed.
Figures may not add due to rounding.

TABLE 2. CANADA, PRODUCTION OF LIMESTONE, 1984-86

	1984		1985		1986	
	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)
By province						
Newfoundland	385	2 333	215	1 479	182	948
Nova Scotia	192	2 125	1 290	6 399	206	2 046
New Brunswick	511	4 083	603	5 123	494	5 195
Quebec	25 124	100 739	26 459	110 025	28 756	121 716
Ontario	31 497	121 716	41 453	162 992	42 849	197 123
Manitoba	1 392	5 682	3 434	10 555	3 253	18 974
Alberta	257	3 346	1 349	6 946	179	1 173
British Columbia	1 848	8 827	2 998	14 098	1 503	9 383
Northwest Territories and Yukon	720	4 590	73	245	342	1 057
Canada	61 928	253 441	77 874	317 862	77 764	357 615
By use						
Building stone						
Rough	167	1 469	179	1 767	..	..
Monumental and ornamental stone (n.f.)	1	75	1	75	..	..
Other (flagstone, curbstone, paving blocks, etc.)	10	665	14	741	..	..
Chemical and metallurgical						
Cement plants, foreign	545	1 489	546	1 527	..	..
Lining, open-hearth furnaces	23	88	-	-	..	..
Flux, iron and steel furnaces	1 002	4 108	1 155	4 893	..	..
Flux, nonferrous smelters	231	2 385	75	1 759	..	..
Glass factories	196	3 093	228	4 357	..	..
Lime kilns, foreign	337	1 293	288	1 159	..	..
Pulp and paper mills	230	2 317	187	1 335	..	..
Sugar refineries	45	240	23	261	..	..
Other chemical uses	620	7 643	569	4 977	..	..
Cement plants, Canadian	+	+	8 264	23 031	..	..
Lime plants, Canadian	+	+	5 137	15 504	..	..
Pulverized stone						
Whiting substitute	30	1 810	27	1 487	..	..
Asphalt filler	31	284	48	495	..	..
Dusting, coal mines	1	18	7	196	..	..
Agricultural purposes and fertilizer plants	1 170	12 252	1 123	13 222	..	..
Other uses	48	506	46	446	..	..
Crushed stone for						
Artificial stone	-	-	-	-	..	..
Roofing granules	72	801	86	926	..	..
Poultry grit	19	417	31	820	..	..
Stucco dash	8	172	11	553	..	..
Rock wool	-	-	-	-	..	..
Rubble and riprap	1 498	7 333	818	3 391	..	..
Concrete aggregate	7 042	28 942	7 042	30 613	..	..
Asphalt aggregate	4 365	17 110	5 715	24 103	..	..
Road metal	21 754	79 468	20 946	80 524	..	..
Railroad ballast	1 674	5 989	984	3 405	..	..
Other uses	20 809	73 474	24 324	96 295	..	..
Total	61 928	253 441	77 874	317 862		

- Nil; .. Not available; + Not provided for; (n.f.) Not finished or dressed.

TABLE 3. CANADA, PRODUCTION OF MARBLE, 1984-86

	1984		1985		1986	
	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)
By province						
Nova Scotia	2	99	2	130	3	151
Quebec	396	4 538	381	5 116	369	5 133
Ontario	105	6 153	188	8 720	189	8 928
Canada	503	10 790	571	13 966	561	14 212
By use						
Building stone						
Rough	-	-	18	665	..	..
Monumental and ornamental stone (n.f.)	5	476	5	535	..	..
Chemical process stone						
Flux in nonferrous smelters	-	-	--	1	..	..
Pulp and paper mills	7	107	5	73	..	..
Other chemical uses	29	996	-	-	..	..
Pulverized stone						
Whiting	-	-	-	-	..	..
Agricultural purposes and fertilizer plants	74	888	95	1 513	..	..
Other uses	108	5 955	200	9 463	..	..
Crushed stone for						
Artificial stone	12	195	10	203	..	..
Roofing granules	1	18	1	31	..	..
Poultry grit	--	1	--	1	..	..
Stucco dash	2	105	3	105	..	..
Terrazzo chips	3	109	5	124	..	..
Concrete aggregate	53	208	32	220	..	..
Road metal	78	284	73	230	..	..
Other uses	131	1 448	124	802	..	..
Total	503	10 790	571	13 966		

- Nil; -- Amount too small to be expressed; .. Not available. (n.f.) Not finished or dressed.

TABLE 4. CANADA, PRODUCTION OF GRANITE, 1984-86

	1984		1985		1986	
	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)
By province						
Newfoundland	85	573	106	616	94	666
Nova Scotia	3 229	14 666	2 582	13 971	2 705	14 742
New Brunswick	1 465	6 139	1 671	6 923	1 724	7 750
Quebec	3 855	26 188	4 371	30 092	4 565	33 500
Ontario	1 645	31 613	2 523	14 834	1 363	15 618
Manitoba	632	5 774	1 242	6 712	846	7 855
Alberta	-	-	-	-	-	-
British Columbia	4 891	29 347	4 695	22 146	2 874	13 431
Northwest Territories and Yukon	-	-	30	130	4	20
Canada	15 802[r]	114 300[r]	17 219	95 424	14 175	93 582
By use						
Building stone						
Rough	54	6 521	57	6 904	..	..
Monumental and ornamental (n.f.)	33	4 950	38	5 399	..	..
Other (flagstone, curbstone, paving blocks, etc.)	6	222	9	500	..	..
Chemical and metallurgical lining, open-hearth furnaces	-	-	-	-	..	..
Pulverized stone						
Asphalt filler	92	440	193	2 657	..	..
Crushed stone for						
Roofing granules	240	21 368	248	458	..	..
Poultry grit	2	147	--	1	..	..
Stucco dash	1	149	4	328	..	..
Rubble and riprap	791	4 232	1 772	6 013	..	..
Concrete aggregate	1 092	5 826	1 506	6 313	..	..
Asphalt aggregate	1 422	6 589	1 150	5 803	..	..
Road metal	2 551	10 771	3 531	15 219	..	..
Railroad ballast	5 712	38 365	4 485	30 085	..	..
Other uses	3 806	14 718	4 225	15 747	..	..
Total	15 802[r]	114 300[r]	17 219	95 424		

- Nil; -- Amount too small to be expressed; .. Not available; [r] Revised; (n.f.) Not finished or dressed.

TABLE 5. CANADA, PRODUCTION OF SANDSTONE, 1984-86

	1984		1985		1986	
	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)
By province						
Newfoundland	79	391	341	1 556	191	1 009
Nova Scotia	907	4 600	1 081	4 901	1 083	4 980
New Brunswick	58	119	260	375	117	58
Quebec	1 061	6 319	1 309	8 054	1 386	8 652
Ontario	8	375	19	353	58	598
Alberta	1	70	1	64	1	57
British Columbia	--	7	--	7	25	235
Canada	2 114	11 881	3 011	15 310	2 861	15 589
By use						
Building stone						
Rough	28	1 274	26	1 247	..	..
Monumental and ornamental (n.f.)	15	488	15	517	..	..
Other (flagstone, curbstone, paving blocks, etc.)	1	51	2	97	..	..
Crushed stone for						
Rubble and riprap	14	14	189	567	..	..
Concrete aggregate	172	940	213	1 300	..	..
Asphalt aggregate	152	706	123	614	..	..
Road metal	313	1 343	501	2 009	..	..
Railroad ballast	3	8	230	919	..	..
Other uses	1 416	7 057	1 712	8 040	..	..
Total	2 114	11 881	3 011	15 310		

-- Amount too small to be expressed; .. Not available. (n.f.) Not finished or dressed.

TABLE 6. CANADA, PRODUCTION OF SHALE, 1984-86

	1984		1985		1986	
	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)
By province						
Newfoundland	9	31	10	34	9	88
Nova Scotia	47	39	1	--	27	25
New Brunswick					9	62
Quebec	510	1 463	429	1 278	990	3 193
Ontario[1]	738	990	857	1 193	1 018	3 862
Manitoba	-	-	1	10	--	2
Alberta	-	-	203	486	50	84
Northwest Territories	8	27	60	59	138	339
Canada	1 312	2 550	1 561	3 060	2 241	7 655
By use						
Chemical and metallurgical						
Cement plants, Canadian	+	+	203	485		
Crushed stone for						
Rubble and riprap	37	157	9	39	..	..
Road metal	363	1 006	220	764	..	..
Other uses	912	1 387	1 129	1 772	..	..
Total	1 312	2 550	1 561	3 060		

[1] Includes slate.

- Nil; -- Amount too small to be expressed; .. Not available; + Not provided.

TABLE 7. CANADA, PRODUCTION OF STONE BY TYPES, 1975, 1980, 1985 AND 1986

	1975		1980		1985		1986	
	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)
Granite	11 470	34 913	39 983	140 914	17 219	95 424	14 175	93 582
Limestone	72 284	152 521	58 191	185 085	77 874	317 862	77 764	357 615
Marble	356	1 843	316	1 807	571	13 966	561	14 212
Sandstone	3 753	10 881	3 064	11 540	3 011	15 310	2 861	15 589
Shale	1 551	2 566	1 812	1 810	1 561	3 060	2 241	7 655
Total	89 414	202 724	103 366	341 156	100 236	445 622	97 602	488 653

Sources: Energy, Mines and Resources Canada; Statistics Canada.

TABLE 8. CANADA, STONE EXPORTS AND IMPORTS, 1985-87

	1985		1986		Jan.-Sept. 1987P	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Exports						
Building stone, rough	12 511	1 657	66 427	2 477	119 728	3 933
Stone crude, n.e.s.	171 450	1 386	329 832	3 016	537 445	4 061
Natural stone, basic products	..	24 381	..	29 186	..	21 463
Total	..	27 424	..	34 679	..	29 457
Imports						
Building stone, rough	8 846	1 379	10 622	1 853	12 837	1 644
Stone crude, n.e.s.	4 096	357	6 257	463	6 580	509
Granite, rough	34 466	6 154	33 995	6 646	32 590	5 616
Marble, rough	6 036	2 716	6 136	2 725	4 540	2 231
Shaped or dressed granite	..	6 278	..	11 224	..	10 867
Shaped or dressed marble	..	5 311	..	8 792	..	10 957
Natural stone basic products	..	9 996	..	15 357	..	16 142
Total	..	32 191	..	47 060	..	47 966

Source: Statistics Canada.
P Preliminary; n.e.s. Not elsewhere specified; .. Not available.

TABLE 9. CANADA, VALUE OF CONSTRUCTION[1] BY PROVINCE, 1985-87

	1985			1986			1987		
	Building Construction	Engineering Construction	Total	Building Construction	Engineering Construction	Total	Building Construction	Engineering Construction	Total
					($000)				
Newfoundland	686 110	1 038 241	1 724 351	808 806	719 888	1 528 694	833 741	604 261	1 438 002
Nova Scotia	1 322 732	1 026 096	2 348 828	1 444 845	828 860	2 273 705	1 500 734	732 121	2 233 055
New Brunswick	995 075	452 480	1 447 555	1 040 536	404 255	1 444 791	1 086 815	464 899	1 551 714
Prince Edward Island	181 128	63 494	244 622	221 222	65 319	286 541	207 931	76 574	284 505
Quebec	10 245 635	4 170 063	14 415 698	11 477 930	4 097 549	15 575 479	11 721 159	4 334 030	16 055 189
Ontario	15 858 300	5 250 869	21 109 169	19 361 442	5 407 360	24 768 802	20 446 162	5 908 798	26 354 960
Manitoba	1 607 763	820 117	2 427 880	1 849 696	895 268	2 744 964	1 802 815	1 047 739	2 850 554
Saskatchewan	1 528 847	1 744 874	3 273 721	1 568 662	1 312 843	2 881 505	1 637 169	1 406 674	3 043 843
Alberta	3 888 425	7 387 129	11 275 554	4 024 940	6 078 331	10 103 271	4 210 469	5 899 695	10 110 164
British Columbia, Yukon and Northwest Territories	5 144 972	4 570 814	9 715 786	5 203 520	3 594 742	8 798 262	5 242 760	3 182 774	8 425 534
Canada	41 458 987	26 524 177	67 983 164	47 001 599	23 404 415	70 406 014	48 689 955	23 657 565	72 347 520

Source: Statistics Canada.

[1] Actual expenditures 1985, preliminary actual 1986, intentions 1987.

Sulphur

M. PRUD'HOMME

SUMMARY

In 1987, world production of sulphur-in-all-forms has been estimated at 59.14 Mt, a 2% increase over 1986; world production of elemental sulphur totalled 37.84 Mt. World consumption of elemental sulphur rose 4% to 37.67 Mt. Trade accounted for 40% of world production of elemental sulphur.

Sulphur production grew in the U.S.S.R., Saudi Arabia and Mexico, remained stable in West Germany, Poland and Canada while it decreased in France and the United States. Consumption recovered in North Africa, India, Mexico and the United States, where the phosphate fertilizer industries benefitted from higher sales and operating rates.

An oversupply situation prevailed during 1987 resulting in a soft pricing structure despite isolated efforts to curtail production and cutback on inventory withdrawals. However, the international phosphate market was in a better balance in 1987 than in 1986, with some recovery in the consumption of fertilizers in India, China, the United States, Turkey and Bangladesh. Inventory buildups were also reported in sulphur consuming countries, particularly Morocco and India.

CANADIAN DEVELOPMENTS

Elemental Sulphur

Canadian elemental sulphur production in 1987 remained stable at 5.7 Mt produced from natural gas processing plants (91%), oil sands plants (8%) and oil refineries. Shipments were estimated at 7.2 Mt, a 4% increase over 1986. Sulphur deliveries in Canada accounted for 8% of total shipments while exports to the United States increased by 33% and accounted for 11%. Offshore shipments remained stable at around 5.8-5.9 Mt with increased sales to Morocco, Mexico, Brasil, Tunisia and Indonesia offsetting the large decline in sulphur exports to the U.S.S.R. Withdrawals from Canadian inventories continued at a 1.2 to 1.5 Mt/y rate leaving stockpiles reserves between 6.9-7.1 Mt by the end of 1987. Canadian sulphur production accounted for 15% of world elemental sulphur production while Canadian supplies accounted for 42% of world brimstone trade.

Shell Canada Limited, with partner Mobil Oil Canada, Ltd., announced its intention to construct a $40 million demonstration project to process super sour natural gas near Bearberry, 15 km northwest of Sundre, Alberta. The five-year program will establish and verify the technical and economic feasibility of processing sour gas with 90% hydrogen sulphide content. The new technology involves the use of solvent oil to dissolve sulphur build-up within the two producing wells and the gas formation. The sulphur facilities will include a four stage Claus processing unit designed for 98% recovery of about 204 t/d of liquid sulphur. The safety of the project is based on an emergency shutdown system (ESD) comprising monitoring devices, electronic alarm displays and shutdown equipment. Plant construction is scheduled to start in early 1988 and is due for completion during 1990. Nearly 150 jobs will be created at the peak of the construction period. Depending on the results of the demonstration project, a commercial operation might be put on-stream in the mid-1990s. Reserves in place within the Bearberry gas field are estimated at 70-100 Mt of sulphur.

In February, Shell Canada Limited discovered major new gas and condensates reserves at Caroline, near Sundre, Alberta. Shell Canada assesses the potential of the find to be of the order of 56.6 billion m^3 of raw gas with a hydrogen sulphide content of 30-35%. The in situ volume recovery is expected to reach 80%. Proven sulphur reserves have been estimated at 2.5 Mt. Shell Canada has a 50% working interest in the discovery pool. Partners include Altana Exploration Company, Canterra Energy Ltd., Union Pacific Resources Inc., Dome Petroleum Limited, Encor Energy Corporation Inc. and Husky Oil Operations Ltd. The field is not expected to start producing

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until the early 1990s but Shell will continue drilling to identify reserves and draw up development plans. The Caroline gas discovery resulted in intense oil and gas exploration activities in the Caroline-Sylvan Lake area of Central Alberta; in late 1987, Shell Canada was successful in extending the reserves of natural gas in this area.

Early in 1987, Texaco Canada Inc. joined Cansulex Limited which has now 22 members. Texaco Canada Inc. operates sour natural gas wells at Bonnie Glen, Alberta, and extracts 35 t/d of elemental sulphur from its sulphur oil refinery at Nanticoke, Ontario.

In October, Suncor Inc. had to shut down its oil sands-bitumen extraction plant near Fort McMurray, Alberta, when a fire caused damages estimated at $50-60 million to the extraction system and building. Prior to the accident, the operation was producing some 9500 m^3/d of synthetic oil and 330 t/d of sulphur. Suncor Inc. plans to resume partial production by the end of January 1988 and reach full production schedule early next April.

Canterra Energy Ltd. commissioned a 108 000 t/y sulphur recovery unit to treat contaminated sulphur block base pad at Ram River, Alberta. The unit uses a cold flotation process designed by Canterra. The block base pad contains 204 000 t of recoverable sulphur with 10% impurities.

Pacific Coast Terminals Co. Ltd. (PCT), located near Port Moody, British Columbia, completed a major modernization project to install an $8.7 million computerized "stakrake" storage and reclaim system of high efficiency. The sulphur handling system replaced three separate stacking and reclaiming systems. The new stockpile capacity is estimated at 250 000 t of sulphur while the stacker-reclaimer functions have a combined capacity of 3000 t/h. PCT is also considering installing a new indexed rotary railcar dumper for bypassing stockpiles and loading sulphur directly from the railcars into ships. PCT is served by CP Rail and handles close to 50% of the solid sulphur exported from Vancouver each year.

Sulphuric Acid

In 1987, the sulphuric acid market in Canada remained relatively stable. In western Canada, strong demand in the pulp and paper sector was offset by the depressed market for fertilizers, resulting in downward pressure on prices. In eastern Canada, demand was strong in the pulp and paper sector which operated at full capacity, and remained stable in the industrial chemicals sector; however, overall domestic demand continued to contract in view of technological changes, curtailment of industrial capacities and increased concerns over the environment.

Cominco Ltd. shut down definitively its fertilizer plant at Kimberley, British Columbia. The plant had a production capacity of 165 000 t/y of ammonium phosphate and 345 000 t/y of sulphuric acid.

Noranda Inc., announced plans to construct a $125 million sulphuric acid plant at its Horne copper smelter in Rouyn-Noranda, Quebec. The plant will have a production capacity of nearly 350 000 t/y of sulphuric acid; three grades of acid will be produced: 93%, 96% and 98%. The project results from an agreement between Noranda, and the federal and Quebec governments to reduce sulphur dioxide emissions by 50% to 276 000 t/y by 1990. Construction will begin in early 1988 for commissioning by mid-1989.

INCO Limited, Hudson Bay Mining and Smelting Co., Limited (HBM&S) and Falconbridge Limited continue their research efforts for reducing sulphur dioxide emissions from smelters in order to comply with the 1994 emission limits set in 1985 by the provincial and federal governments.

A pilot plant for recycling sulphuric acid was constructed in Tracy, Quebec, for the treatment of industrial wastes from the sulphate processing of titanium dioxide. The $6 million plant was commissioned during the summer of 1987, under a joint venture project between Chemetics International Company, NL Chem Canada, Inc., Tioxide Canada Inc. and QIT-Fer et Titane Inc. The clean-up program is expected to result, by 1991, in an 85% reduction of the amount of pollutants being discharged in the St. Lawrence River through the elimination of strong acids.

In September 1987, Western Co-operative Fertilizers Limited mothballed its Calgary fertilizer plant which had a capacity of 60 000 t/y of ammonia, 65 000 t/y of nitric acid and 430 000 t/y of sulphuric acid. These chemicals were used captively to produce fertilizers. In April 1987, Western Co-op moved its Medicine Hat's 359 000 t/y sulphuric acid plant to the company's Calgary facilities, replacing two older units which had a combined production capacity of 390 000 t/y.

WORLD DEVELOPMENTS

Elemental Sulphur

The U.S.S.R. will be the main world supplier of additional sulphur over the next five years. Sulphur production in the U.S.S.R. is expected to grow by close to 5 Mt/y to reach 10 Mt/y of recovered sulphur by 1993 as a result of the development of sour natural gas and oil fields at Astrakhan and Tenguiz.

The first phase of Astrakhan at 2.5 Mt/y of sulphur came on-stream in January 1987; most of the molten sulphur shipments from this processing plant is expected to be used domestically by the developing phosphate fertilizer industry in the southern U.S.S.R. Despite some production disruptions due to gas leakage in the second quarter of 1987, the plant should have reached 50% of its production capacity by the end of 1987, and may reach full capacity in 1988. The immediate impact of the start-up of Astrakhan I was a sharp drop in elemental sulphur imports by the U.S.S.R. The Astrakhan II gas processing plant is expected to be commissioned in 1989 to reach a normal operating rate around the mid-1990s. Capacity expansions are planned at Tenguiz over the medium to long term.

The supply of sulphur from the Soviet Union will, for a number of years, remain the largest uncertainty in the world supply-demand balance. However, the plants at Astrakhan may not operate at capacity for several years after production starts due to uncertainties in the markets for natural gas. The U.S.S.R. may engage in countertrade agreements with foreign phosphate rock producers in exchange for sulphur, since the U.S.S.R. is reported to be committed to modernize and expand its fertilizer sector and may be deficient in phosphate resources. It has been reported that exports of sulphur to western Europe and North Africa may start as early as 1988.

The United States is the world's major Frasch producing country; production of elemental sulphur in 1987 dropped 4% to 9.6 Mt, of which Frasch sulphur accounted for 31% and recovered sulphur for 58%. Imports of sulphur increased 41% to 1.7 Mt mainly from Mexico (54%) and Canada (43%). Sulphur exports declined by 49% to 1.26 Mt. Producers' stocks at the end of the year totalled 2.3 Mt (2.7 Mt in 1986). Sulphur was mainly used in agricultural chemicals and fertilizers (70%), inorganic chemicals (11%) and petroleum refining (7%). Texasgulf Inc. announced its intentions to reactivate a Frasch sulphur mine mothballed in 1983 at Commanche Creek in west Texas; the 365 000 t/y mine is expected to be on-stream by the end of 1988. Freeport-McMoRan Inc. of New Orleans plans to recommission its Caminada sulphur mine, offshore from Louisiana; production capacity of the mine is in the range of 500-600 000 t/y and reserves have been estimated at 5.7 Mt.

Poland is the second largest exporter of elemental sulphur after Canada. Production in 1987 was estimated at 4.9 Mt of Frasch sulphur mined at the Jeziorko and Grzybow operations. The depletion of sulphur reserves at the Grzybow mine resulted in the development of the new 1.2 Mt/y Oziek Frasch mine which is expected to be on-stream in late 1988. Poland exports 74% of its production, mainly in eastern Europe (53%), western Europe (26%), and South America (9%).

Mexico produced 2.2 Mt of sulphur, of which 1.9 Mt was Frasch. Domestic consumption was around 1.1 Mt while exports amounted to 1 Mt. Sulphur production is expected to grow starting in 1988 due to the commissioning of the new Otapan Frasch sulphur mine in southern Mexico. The operation has a designed production capacity of 545 000 t/y. Mexican sulphur production is expected to reach 2.35 Mt by 1990.

In Saudi Arabia, sulphur production in 1987 totalled 1.35 Mt, a 22% increase over 1986. Exports reached 800 000 t for markets in India, Europe and North Africa. Sulphur is produced at three gas refineries and is stockpiled at the Berri gas plant where inventories are estimated at about 1.3 Mt. Increasing tension in the Persian Gulf slightly affected sulphur deliveries to foreign markets since close to 90% of Saudi sulphur exports were through the Gulf.

China is reported to have commissioned a new 3 Mt/y pyrite mine near Yunfu in the Guandong Province of southern China. China's commitment to become self-sufficient in commodities such as sulphur has ended imports of elemental sulphur from Canada since 1986. However, in anticipation of the growing needs of its agricultural sector, China is expected to require large volumes of foreign sulphur as consumption of elemental sulphur should reach 2.5 Mt/y by 1990.

PRICES

Contract prices for offshore exports of elemental sulphur from Vancouver showed a steady decline during 1987, starting at US$102-110 a tonne in January and dropping to US$88-99 a tonne in the second half of 1987, a 25% drop over 1986.

Spot prices ranged between US$95-98 a tonne during the first half of 1987 and remained weak in the second half at US$90-96 a tonne. The US$3 a tonne difference between contract and spot prices remained fairly constant all year long.

Sulphuric acid prices in Canada remained fairly stable at $60 to $70 a tonne on the spot market. Weak demand for fertilizers in western Canada resulted in downward pressures on prices; however, the profitability of sulphur burning operations recovered in the fourth quarter as elemental sulphur prices remained low.

USES

About 60% of all the sulphur consumed in the world is used in the production of fertilizers such as superphosphates, ammonium phosphate, and ammonium sulphate. The second largest consuming sector is the chemical industry where sulphur is used in products ranging from pharmaceuticals to synthetic fibres in plastics and petroleum catalysts. Other consumers of sulphur include the manufacture of titanium dioxide used in paint, enamels, paper, and ink; iron and steel; and nonferrous metals. These consuming industries use sulphur in the form of sulphuric acid which accounts for almost 90% of total sulphur consumption (60% of sulphuric acid consumption is in fertilizers). Products requiring sulphur in the non-acid form include insecticides and fungicides, pulp and paper, photography, leather processing, rayon, rubber, etc.

OUTLOOK

The sulphur market is still fundamentally oversupplied with discretionary and non-discretionary producers' deliveries. In the short term, a fine balance between supply and demand is expected to result in a fairly stable pricing structure.

The future of Canada as a major sulphur supplier is tied to international market conditions and domestic capabilities. The Canadian production of sulphur will likely remain highly dependent on the oil and gas markets; however, new sources are being considered, notably the processing of super sour gas (60 to 90% H_2S) as a discretionary source of elemental sulphur, and non-discretionary sources of recovered sulphur such as oil shales and tar sands.

The international sulphur market is becoming more competitive. For the last seven years, demand has exceeded production and inventory withdrawals were instrumental in supplementing production. Over the next few years, supply is forecast to meet demand through additional sulphur production and continuing inventory drawdowns. Future world sulphur demand is highly dependent on growth in demand for phosphate fertilizer. Phosphate consumption in developed countries is expected to increase marginally over the next five years; however, growth in phosphate demand is anticipated in developing countries and the Centrally Planned Economy countries. Overall growth in world phosphate demand has been forecast to range between 2 and 2.5% annually for the period 1985-90, while industrial consumption of sulphur is expected to remain fairly stable; consequently, world sulphur demand is forecast to grow at an annual rate of about 1.5% for the next three years.

On the supply side, some sulphur producers are expected to register declining or stable production, notably West Germany, France, Japan, and Poland while other countries are expected to show increased production capacities, namely, the United States, Mexico, Saudi Arabia, the U.S.S.R. and Canada. However, the U.S.S.R. is the greatest uncertainty as its sulphur production capacity is projected to more than double by 1995. If everything goes according to plan in the U.S.S.R., there is potential for global oversupply. The uncertainty rests not only with the rate of development of the new Soviet facilities, but with the level of gas exports to western Europe in an environment of oversupply.

In the long term, the growth in capacity of production may offset the depletion of inventories in Canada, France, Mexico, Saudi Arabia and the United States. Improved profitability in the international market due to growth in demand will likely spur the development of projects in sulphur production, notably discretionary sources such as super sour gas, Frasch and volcanic deposits.

PRICES

	1987
	C$/t
Canadian elemental sulphur net-back values[1], f.o.b. plant	
North American deliveries	80.90
Offshore deliveries	76.02
Canadian sulphuric acid price[2]	
F.o.b. plant, East, 66° Be, (93%) tanks	115.00
	US$/st
American elemental sulphur prices[3]	
U.S. producer, term contract, f.o.b. vessel at Gulf ports	
Louisiana and Texas	
Bright	147.50
Dark	141.50
Export prices, ex-terminal Holland	
Bright	164.50-167.50
Dark	155.00
American sulphuric acid prices[4]	
Sulphuric acid, virgin, 100% tank works	
East Coast	71.75
Gulf Coast	75.00
Midwest	80.25
Southeast	68.15
West Coast	85.00
Sulphuric acid, smelter, 100% tank works	
Gulf Coast	48.00
New Mexico	20.00
Southeast	63.15
Northwest, (93%)	60.00

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[1] Alberta Energy Resources Industries, Monthly Statistics, September 1987. [2] Corpus Chemical Report, November 1987. [3] Engineering and Mining Journal, October 1987. [4] Chemical Marketing Reporter, December 1987.
F.o.b. Free on board.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
CANADA					
92503-1	Sulphur of all kinds, other than sublimed sulphur, precipitated sulphur and colloidal sulphur	free	free	free	free
92802-1	Sulphur, sublimed or precipitated; colloidal sulphur	free	free	free	free
92807-1	Sulphur dioxide	free	free	free	free
92808-1	Sulphuric acid, oleum	free	free	25	free
92813-4	Sulphur trioxide	free	free	free	free
UNITED STATES					
418.90	Pyrites		free		
415.45	Sulphur, elemental		free		
416.35	Sulphuric acid		free		
422.94	Sulphur dioxide		4.2		

Sources: The Customs Tariff, 1987 Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1987), USITC Publication 1910; U.S. Federal Register, Vol. 44, No. 241.

TABLE 1. CANADA, SULPHUR SHIPMENTS AND TRADE, 1985-87

	1985		1986		1987P	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Shipments						
Sulphur in smelter gases[1]	822 359	86 342	758 231	72 614	802 512	93 269
Elemental sulphur[2]	8 102 163	1 026 202	6 965 775	857 584	6 887 646	650 762
Total sulphur content	8 924 522	1 112 544	7 724 006	930 198	7 690 158	774 031
					(Jan.-Sept.)	
Imports						
Sulphur, crude or refined						
United States	3 154	1 079	10 723	2 587	4 147	663
Other countries	13	4	40	9	21	6
Total	3 167	1 083	10 763	2 696	4 168	669
Sulphur, liquid						
United States	1 532	439	8 597	2 172	12 206	2 766
Other countries	-	-	-	-	-	-
Total	1 532	439	8 597	2 172	12 206	2 766
Sulphuric acid, including oleum						
United States	17 297	2 075	19 402	2 511	30 159	2 755
West Germany	4	..	15	2	31	4
Other countries	5	1	9 710	573	111	10
Total	17 306	2 076	29 126	3 086	30 307	2 769
Exports						
Sulphuric acid, including oleum						
United States	702 940	18 738	755 594	25 236	554 527	18 574
Other countries	41 792	1 778	12	27	17	99
Total	744 732	20 516	755 606	25 263	594 546	18 673
Sulphur, crude or refined, n.e.s.						
United States	1 363 596	144 285	610 328	69 927	569 973	53 806
Brasil	620 054	112 237	479 929	91 620	387 514	58 732
Morocco	826 499	154 824	738 970	139 175	966 943	139 382
Tunisia	395 161	75 404	316 915	60 383	285 710	39 652
South Africa	417 822	71 276	319 803	59 249	126 592	19 220
Australia	396 442	68 812	441 916	81 392	307 297	45 170
South Korea	506 357	88 301	425 974	78 069	317 442	45 974
People's Republic of China	162 576	30 016	-	-	-	-
U.S.S.R.	294 415	51 850	848 080	158 758	60 338	9 437
Finland	177 301	30 159	-	-	-	-
India	482 583	83 889	243 848	39 356	116 990	16 168
Israel	228 065	27 874	179 796	23 835	173 627	24 010
Taiwan	185 027	33 810	228 653	40 535	103 790	14 318
Netherlands	144 534	26 592	274 957	52 662	173 070	24 893
France	108 334	19 819	89 902	17 068	73 013	10 903
New Zealand	213 788	38 554	77 419	14 272	74 430	11 087
Other countries[3]	1 325 826	232 988	981 564	926 301	1 042 968	151 274
Total	7 848 380	1 290 690	6 257 054	1 108 873	4 779 697	664 026

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Sulphur in liquid SO_2 and H_2SO_4 recovered from the smelting of metallic sulphides and from the roasting of zinc-sulphide concentrates. [2] Producers' shipments of elemental sulphur produced from natural gas; also included are small quantities of sulphur produced in the refining of domestic crude oil and synthetic crude oil. [3] Mainly Belgium-Luxembourg, Italy, Senegal, Indonesia, Argentina, Chile, Cuba, and Mozambique.

P Preliminary; - Nil; .. Not available; n.e.s. Not elsewhere specified.

TABLE 2. CANADA, SOUR GAS AND OIL SANDS SULPHUR EXTRACTION PLANTS, 1985-87

Operating Company	Source Field or Plant Location	H_2S in Raw Gas	Daily Sulphur Capacity		
			1985	1986	1987
	(Alberta, except where noted)	(%)		(tonnes)	
Sour Gas					
Amerada Hess Corporation	Garrington	13	389	389	389
Amoco Canada Petroleum Company Ltd.	Bigstone Creek	19	382	382	382
Amoco Canada Petroleum Company Ltd.	East Crossfield-Elkton	26	1 797	1 797	1 797
Canadian Occidental Petroleum Ltd.	Okotoks	-	-	835	577
Canadian Occidental Petroleum Ltd.	Paddle River	1	19	19	19
Canadian Superior Oil Ltd.	Harmattan-Elkton	56	515	515	490
Canadian Superior Oil Ltd.	Lone Pine Creek	12	157	157	157
Canterra Energy Ltd.	Brazeau River	2	42	42	42
Canterra Energy Ltd.	Okotoks	34	431	431	431
Canterra Energy Ltd.	Rainbow Lake	4	139	139	139
Canterra Energy Ltd.	Ram River (Ricinus)	19	4 572	4 572	4 572
Canterra Energy Ltd.	Windfall	8	1 199	1 199	1 330
Chevron Standard Limited	Kaybob South	20	3 537	3 557	3 557
Chevron Standard Limited	Nevis	7	-	-	-
Chieftain Development Co. Ltd.	Sinclair	5	256	256	256
D.M. Wolcott & Associates Ltd.	Brazeau (W. Pembina)	-	294	300	340
Dome Petroleum Limited	Steelman, Sask.	1	7	7	7
Esso Resources Canada Limited	Joffre	11	17	17	17
Esso Resources Canada Limited	Ouirk Creek	9	293	293	299
Esso Resources Canada Limited	Redwater	4	33	33	11
Gulf Canada Limited	Homeglen-Rimbey	2	333	128	128
Gulf Canada Limited	Nevis	7	295	295	197
Gulf Canada Limited	Pincher Creek	5	-	-	-
Gulf Canada Limited	Strachan	9	943	943	953
Gulf Canada Limited	Hanlan Robb	9	1 092	1 092	1 092
Home Oil Company Limited	Carstairs	1	65	65	65
Hudson's Bay Oil and Gas Company Limited (HBOG)	Brazeau River	1	110	110	110
Hudson's Bay Oil and Gas Company Limited (HBOG)	Caroline	1	8	8	8
Hudson's Bay Oil and Gas Company Limited (HBOG)	Edson	2	284	284	288
Hudson's Bay Oil and Gas Company Limited (HBOG)	Kaybob South (1)	13	1 086	1 086	1 086
Hudson's Bay Oil and Gas Company Limited (HBOG)	Kaybob South (2)	17	1 085	1 086	1 086
Hudson's Bay Oil and Gas Company Limited (HBOG)	Lone Pine Creek	10	283	283	283
Hudson's Bay Oil and Gas Company Limited (HBOG)	Sturgeon Lake	12	98	98	98
Hudson's Bay Oil and Gas Company Limited (HBOG)	Zama	8	74	74	74
Mobil Oil Canada, Ltd.	Wimborne	14	182	182	182
Mobil Oil Canada, Ltd.	Teepee	4	30	30	30
PanCanadian Petroleum Limited	Morley	5	18	18	-
Petro-Canada	Brazeau	-	80	80	88
Petro-Canada	Gold Creek	5	43	43	43
Petro-Canada	Wildcat Hills	4	177	177	177

TABLE 2. (cont'd)

Operating Company	Source Field or Plant Location (Alberta, except where noted)	H_2S in Raw Gas (%)	Daily Sulphur Capacity 1985	1986	1987
			(tonnes)		
Petrogas Processing Ltd.	Crossfield (Balzac)	14	1 696	1 696	1 696
Saratoga Processing Company Limited	Savannah Creek (Coleman)	20	389	389	389
Shell Canada Limited	Burnt Timber Creek	10	489	489	489
Shell Canada Limited	Innisfail	23	163	163	163
Shell Canada Limited	Jumping Pound	6	566	566	597
Shell Canada Limited	Progress	-	25	25	15
Shell Canada Limited	Rosevear	8	171	171	171
Shell Canada Limited	Simonette River	7	95	95	95
Shell Canada Limited	Waterton	17	3 148	3 148	3 107
Sulpetro Limited	Minnehik-Buck Lake	1	45	45	45
Suncor Inc.	Rosevear	8	110	110	110
Texaco Exploration Company	Bonnie Glen	-	12.5	12.5	12.5
Westcoast Transmission Company Limited	Fort Nelson, B.C.		1 100	1 100	1 100
Westcoast Transmission Company Limited	Taylor Flats, B.C.	3	460	460	460
Westcoast Transmission Company Limited	Pine River (Hasler Flats), B.C.			1 055	1 055
Western Decalta Petroleum Limited	Turner Valley	1	11	11	11
Oil Sands					
Suncor Inc.	Mildred Lake	-	300	300	300
Syncrude Canada Ltd.	Mildred Lake	-	950	950	950

Sources: From Alberta Energy Resources Conservation Board publications, October 1987; Oilweek, January 1985, 1986 and 1987.
- Nil.

TABLE 3. CANADIAN PETROLEUM REFINERY SULPHUR CAPACITIES, 1985-87

Operating Company	Location	Daily Capacity 1985	1986	1987
			(tonnes)	
Canadian Ultramar Limited	St. Romuald, Quebec	81	82	82
Chevron Canada Limited	Burnaby, British Columbia	10	10	10
Consumers' Co-operative Refineries Limited	Regina, Saskatchewan	18	16	16
Husky Oil Ltd.	Prince George, British Columbia	5	5	5
Imperial Oil Limited	Dartmouth, Nova Scotia	76	76	76
	Edmonton, Alberta	40	40	40
	Port Moody, British Columbia	20	20	20
	Sarnia, Ontario	140	140	140
Irving Oil Limited	Saint John, New Brunswick	200	200	200
Petro-Canada Products Inc.	Clarkson-Mississauga, Ontario	41	41	41
	Edmonton, Alberta	56	56	56
	Oakville-Trafalgar, Ontario	41	41	41
	Port Moody, British Columbia	25	25	25
Shell Canada Limited	Burnaby, British Columbia	15	15	15
	Sarnia, Ontario	31	35	35
	Scotford, Alberta	10	10	14
Sulconam Inc.	Montreal, Quebec	300	300	300
Suncor Inc.	Sarnia, Ontario	10	49	50
Texaco Canada Inc.	Nanticoke, Ontario	8	32	35
Total		1 127	1 193	1 201

Sources: Oilweek; Mineral Policy Sector, Energy, Mines and Resources Canada.
- Nil.

TABLE 4. CANADA, PRINCIPAL SULPHUR DIOXIDE AND SULPHURIC ACID PRODUCTION CAPACITIES, 1987

Operating Company	Plant Location	Raw Material	Annual Capacity Liquefied SO_2	 Sulphuric Acid[1]	 Sulphur Equivalent[2]
				(000 tonnes)	
Brunswick Mining and Smelting Corporation Limited	Belledune, New Brunswick	SO_2 lead zinc		176	58
C-I-L Inc.	Beloeil, Quebec	elem. sulphur		65	21
Canadian Electrolytic Zinc Limited (CEZ)	Valleyfield, Quebec	SO_2 zinc conc.		440	144
Falconbridge Limited	Sudbury, Ontario	SO_2 nickel conc.		355	116
Gaspé Copper Mines, Limited	Murdochville, Quebec	SO_2 copper		160	52
Inco Metals Company	Copper Cliff, Ontario	SO_2 pyrrhotite and nickel conc.		550	180
	Copper Cliff, Ontario	SO_2 copper conc.	82-90	-	45
Kidd Creek Mines Ltd.	Kidd Creek, Ontario	SO_2 zinc conc.		220	72
	Kidd Creek, Ontario	SO_2 copper conc.		340	111
NL Chem Canada, Inc.	Varennes, Quebec	liquid sulphur		56	18
Subtotal, Eastern Canada			82-90	2 362	817
Border Chemical Company Limited	Transcona, Manitoba	elem. sulphur		150	49
C-I-L Inc.	Fort Saskatchewan, Alberta	elem. sulphur		146	48
Cominco Ltd.	Prince George, British Columbia	elem. sulphur		35	11
	Kimberley, British Columbia[3]	elem. sulphur, SO_2 pyrrhotite		305	100
	Trail, British Columbia[4]	SO_2 zinc and lead conc.	75	430	206
Eldorado Resources Limited	Rabbit Lake, Saskatchewan	elem. sulphur		72	23
Esso Chemical Canada	Redwater, Alberta	elem. sulphur		910	297
Key Lake Mining Corporation	Key Lake, Saskatchewan	elem. sulphur		72	23
Sherritt Gordon Mines Limited	Fort Saskatchewan, Alberta	elem. sulphur		233	75
Sulco Chemicals Ltd.	Elmira, Ontario	elem. sulphur		33	11
Western Co-operative Fertilizers Limited	Calgary, Alberta	elem. sulphur		397	129
Subtotal, Western Canada			75	2 783	972
Total			157-165	5 076	1 768

[1] 100% H_2SO_4. [2] Elemental sulphur equivalent of sulphuric acid is 32.7% and sulphur equivalent of liquefied sulphur dioxide is 50%. [3] Cominco closed its Kimberley facilities during 1987. [4] Cominco operation at Trail has also a 28 000 t/y production capacity for elemental sulphur, which has been added to the total sulphur equivalent production capacity of Cominco.
- Nil.

TABLE 5. CANADA, SULPHUR SHIPMENTS AND TRADE, 1970, 1975 AND 1980-87

	Shipments[1]				Imports	Exports
	Pyrites	In Smelter Gases	Elemental Sulphur	Total	Elemental Sulphur	Elemental Sulphur
			(tonnes)			
1970	159 222	640 360	3 218 973	4 018 555	48 494	2 711 069
1975	10 560	694 666	4 078 780	4 784 006	14 335	3 284 246
1980	14 328	894 732	7 655 723	8 564 783	1 767	6 850 143
1981	5 000	783 000	8 018 000	8 806 000	4 633	7 309 216
1982	9 000	627 000	6 945 000	7 581 000	2 159	6 111 444
1983	-	678 286	6 631 123	7 309 409	2 365	5 670 275
1984	-	844 276	8 352 978	9 197 254	3 019	7 326 847
1985	-	822 359	8 102 163	8 924 522	3 167	7 848 380
1986	-	758 231r	6 965 775r	7 724 006	10 763	6 257 054
1987	-	802 512P	6 887 646P	7 690 158P	..	..

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] See footnotes for Table 1.

P Preliminary; - Nil; .. Not available; r Revised.

TABLE 6. CANADA, SULPHURIC ACID PRODUCTION, TRADE AND APPARENT CONSUMPTION, 1970, 1975, AND 1980-86

	Production	Imports	Exports	Apparent Consumption
		(tonnes - 100% acid)		
1970	2 475 070	9 948	129 327	2 355 691
1975	2 723 202	154 020	225 402	2 651 820
1980	4 295 366	18 048	323 775	3 989 639
1981	4 116 860	82 495	337 518	3 861 837
1982	3 130 854	192 514	259 740	3 063 628
1983	3 686 427	126 573	273 204	3 539 796
1984	4 043 389	28 330	553 780	3 517 939
1985	3 890 092	17 306	744 732	3 162 666
1986	3 536 062	29 127	755 606	2 809 583

Sources: Statistics Canada; Energy, Mines and Resources Canada.

TABLE 7. WORLD PRODUCTION OF SULPHUR, 1984-86

	1984r		1985		1986	
	All-forms[1]	Elemental	All-forms	Elemental	All-forms	Elemental
	(000 tonnes)					
World Total	**54 557**	**33 854**	**56 203**	**35 609**	**56 790**	**36 159**
Western World	**34 772**	**23 986**	**36 800**	**25 600**	**36 674**	**25 524**
Western Europe	**7 760**	**3 620**	**7 854**	**3 555**	**7 786**	**3 381**
Finland	519	45	525	45	545	42
France	1 934	1 751	1 723	1 546	1 326	1 147
West Germany	1 746	1 130	1 778	1 218	1 836	1 276
Italy	436	112	551	121	637	230
Norway	273	8	263	10	261	12
Spain	1 343	20	1 390	20	1 461	25
Others	1 509	554	1 624	625	1 720	649
Africa	**949**	**87**	**1 043**	**95**	**1 005**	**120**
South Africa	771	85	842	85	814	110
Others	178	2	201	10	191	10
Asia, Middle East	**4 909**	**2 879**	**5 639**	**3 473**	**6 046**	**3 898**
Japan	2 762	1 145	2 671	1 068	2 541	998
Saudi Arabia	847	847	1 162	1 162	1 350	1 350
Others	1 300	887	1 806	1 243	2 155	1 550
Oceania	**264**	**40**	**221**	**20**	**244**	**36**
North America	**18 180**	**15 092**	**19 255**	**16 152**	**18 623**	**15 609**
Canada	6 612	5 685	6 679	5 828	6 636	5 750
United States	11 568	9 407	12 576	10 324	11 987	9 859
Latin America	**2 710**	**2 267**	**2 788**	**2 304**	**2 970**	**2 480**
Mexico	1 941	1 856	2 022	1 937	2 190	2 105
Others	769	411	766	367	780	375
Eastern Europe	**6 855**	**5 188**	**6 578**	**5 079**	**6 663**	**5 105**
Poland	5 158	4 990	5 044	4 876	5 061	4 893
Others	1 697	198	1 534	203	1 602	208
U.S.S.R.	9 394	4 510	9 686	4 760	10 150	5 230
China	3 307	170	2 928	170	3 092	300
Other countries[2]	229	0	210	0	211	0

Source: The British Sulphur Corporation Limited, May-June 1987.

[1] All-forms includes elemental sulphur, sulphur contained in pyrites and contained sulphur recovered from metallurgical waste gases, mostly in the form of sulphuric acid. [2] Includes North Korea, Vietnam and Cuba.

r Revised.

TABLE 8. CANADA, SULPHURIC ACID, REPORTED CONSUMPTION BY END USE, 1982-86

	1982	1983	1984	1985	1986P
			(tonnes)		
Fertilizers and other chemicals	2 353 015	2 404 399	2 715 003	2 299 868	2 155 792
Pulp and paper mills	257 863	290 932	295 374	385 719	347 806
Uranium mines	339 294	300 236	365 002	338 909	309 821
Smelting and refining	219 675	211 649	198 343	129 921	129 922
Petroleum refineries and coal products	31 201	34 365	29 713	27 950	35 138
Miscellaneous metal mines	44 535	12 111	15 629	19 562	26 846
Leather and textile	..	31 424	27 774	20 634	22 220
Electrical products industries	17 150	22 230	17 709	19 790	17 097
Soap and cleaning compounds	15 323	11 544	14 494	17 172	16 482
Miscellaneous manufacturing industries	10 861	10 434	15 905	11 149	13 666
Explosives and miscellaneous chemicals	56 527	38 003	40 680	34 758	12 333
Iron and steel mills	7 406	6 360	6 209	8 086	11 524
Plastics and synthetic resins	39 299	5 606	9 439	729	9 138
Crude petroleum and natural gas industry	4 449	4 174	8 116	11 983	8 000
Sugar, vegetable oil, food processor	2 253	837	8 591	5 776	6 871
Other end uses[1]	33 146	31 927	25 592	20 686	38 034

Sources: Reports from producing companies; compiled by Mineral Policy Sector, Energy, Mines and Resources Canada.

[1] Other end uses include miscellaneous nonmetal mines; automotive; municipal utilities; metal fabricating; and other manufacturing industries.

P Preliminary; .. Not available.

Talc, Soapstone and Pyrophyllite

D.J. SHAW AND M.A. BOUCHER

SUMMARY

Talc is a hydrous magnesium silicate with physical properties such as extreme softness and whiteness, a high fusion point, low thermal and electrical conductivity, and is chemically inert; the combination of which allows the mineral to be versatile in its application. In fine-ground state talc is used primarily as a reinforcement filler in ceramics and plastics, a bulk filler and coating pigment in paper, a pitch control agent in pulp and a dusting agent in asphalt roofing and rubber products.

Pyrophyllite is a hydrous aluminum silicate with physical properties similar to talc, which consequently enables the mineral to find similar uses. The major market application for pyrophyllite is in ceramics, followed by refractories and insecticides industries.

Reported Canadian consumption of talc was 64 640 t in 1986, approximately the same as reported in 1985. The pulp and paper industry accounts for 37% of Canadian consumption, followed by the asphalt roofing industry with 31% and the paint industry with 12%. Total imports of talc, soapstone and pyrophyllite in the first nine months of 1987 were 36 976 t, with an associated value of $6 414 000. When compared to the same nine months of 1986, talc imports increased 19% while the average imported talc price fell 19% to $174.91.

Talc is produced in Canada by two companies located in Ontario, Steetley Talc Inc. and Canada Talc Industries Limited, and two companies located in Quebec, LUZCAN Inc. and Bakertalc Inc. Pyrophyllite is produced in Newfoundland by Newfoundland Minerals Limited. Canadian production of talc and pyrophyllite rose 15% to 141 223 t in 1987. All four talc producers have completed recent expansions of their operations and at least two new prospective producers are developing their deposits for potential entry to the industry.

World production of talc and pyrophyllite fell by 1.5% to 7.7 Mt in 1986. The United States, Brazil, Finland and India are the four dominant producers of talc; while Japan, South Korea, the United States and India are the leading four producers of pyrophyllite.

The outlook for the talc industry is for prosperous growth. Talc consumption, if uninhibited by American legislation concerning the tremolitic content of certain talcs which find particular acceptance in ceramics and paint, should grow faster than the economy as a whole. Talc in plastics, primarily for automotive applications, will be the primary catalyst. Prospects of increased demand for ceramic products and substitution of relatively cheap industrial mineral fillers for expensive wood fibre in the production of paper present considerable opportunities for increased world consumption and production of talc.

MINERALOGY AND GEOLOGY

Talc is a hydrous magnesium metasilicate with a theoretical formula of $Mg_3Si_4O_{10}(OH)_2$ and is made up of 63.5% SiO_2, 31.7% MgO and 4.8% H_2O. However, the chemical composition of talc found in nature is quite variable. The mineral is usually intimately associated with numerous other minerals such as serpentine, dolomite and quartz. Its colour is characteristically pale green, grey or creamy white. Talc exhibits a pearly lustre, a low hardness, a greasy feel and an extreme smoothness, and is valued for its various properties: extreme whiteness and smoothness; high fusion point; low thermal and electrical conductivity; and chemical inertness.

Talc is derived from the alteration of magnesium rock in an intensive metamorphic environment. The most common host rocks for the formation of talc are dolomite and ultramafic rocks, but deposits associated with sedimentary rocks, ultramafic igneous rocks and mafic igneous rocks are common.

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The mineral occurs as veinlets, tabular bodies or irregular lenses.

Steatite (soapstone) is an impure, massive, compact form of talc which can be sawn or machined to required shapes. "Steatite grade" is a special block talc suitable for making ceramic insulators. Soapstone is a mixture of talc, serpentine, chlorite and dolomite, sometimes with small percentages of quartz and calcite. Its durability depends on its chemical inertness and non-absorbency properties.

Pyrophyllite is a hydrous aluminum silicate with a theoretical formula of $Al_2Si_4O_{10}(OH)_2$, and is made up of 28.3% Al_2O_3, 66.7% SiO_2 and 5.0% water. It is formed by hydrothermal alteration of acid igneous rocks, predominantly lavas which are andesitic to rhyolitic in composition. The mineral occurs in low and medium grade metamorphic rocks rich in aluminum. Pyrophyllite's physical properties are practically identical to those of talc, and, for this reason, finds industrial uses similar to talc.

CANADIAN DEVELOPMENTS

Consumption and Trade

Reported Canadian consumption of talc remained fairly constant from 1985 to 1986. Survey results indicate that pulp and paper production accounted for 36.7% of total Canadian talc consumption in 1986, asphalt roofing accounted for 31.2% and paint accounted for 11.9%. Stagnant demand in 1986 was primarily a result of reduced consumption from rubber producers.

Imports of talc, soapstone and pyrophyllite for the first nine months of 1987 were 36 196 t, 296 t and 484 t, respectively. The value of these imports was $6 414 000. When compared to the same period in 1986, total imports of talc, soapstone and pyrophyllite increased by 18.9%, while unit prices of talc fell on average by 19.4% to $174.91. The United States accounted for 99% of total imports.

Production and Deposits

In 1987, Canadian production of talc and pyrophyllite grew 14.8% to 141 223 t. The associated value of these shipments also increased to $16 119 460, up 13.7% from 1986. However, over the same period, the average unit price of Canadian shipments of talc and pyrophyllite declined less than 1% from $115.27 to $114.14. Nineteen eighty-six production placed Canada as the fourteenth leading talc and pyrophyllite producer country in the world.

Currently Canadian talc is produced in Ontario and Quebec, while pyrophyllite is only produced in Newfoundland. The bulk of increased shipments in 1987 originated from Newfoundland, with pyrophyllite shipments up 44.4%. Talc production increased in Ontario and accounted for 63.3% of the nation's total, while Quebec's production declined and accounted for 36.7%.

Talc

Steetley Talc Inc., a division of Steetley Industries Limited, produces talc from an open-pit mine in Penhorwood Township, 70 km southwest of Timmins. Talc occurs in talc-magnesite deposits derived from the alteration of ultrabasic volcanic rocks. The ore is processed by flotation methods and is fine-ground to a high purity, platy product. Steetley produces filler products for paint, paper, plastics and rubber, as well grades for cosmetics and as a pitch control agent for the pulp industry. R.T. Vanderbilt Co. Inc. is Steetley's sole distributor to the U.S. market. R.T. Vanderbilt's subsidiary Gouverneur Talc Co. Inc. produces talc from New York state, talc products which are complementary to Steetley's products. By 1987, Steetley Talc Inc. completed its expansion program which began in 1982. The program included an increase in production capacities for new grades, a feasibility study for the production of magnesite and testing of new technology for extraction by continuous mining techniques. Current production capacity is 55-64 000 t/y, depending on product mix.

Canada Talc Industries Limited operates an underground mine and also quarries a newly-discovered talc orebody at Madoc, Ontario. The orebodies occur in crystalline dolomite, where tabular hydrothermal replacements have taken place. The talc is of exceptional whiteness but may contain accessory minerals such as sulphides, mica and prismatic tremolite. The company produces both talc and dolomite from the new orebodies, and present production capacity at the Marmora, Ontario plant is approximately 55 000 t/y.

Bakertalc Inc. produces talc and soapstone from an underground operation at

South Bolton, Quebec, 95 km southeast of Montreal. Talc occurs as dykes and sills, associated with serpentine and magnesite, in Cambrian and Lower Ordovician schists. The ore is extracted from the Van Reet mine and is trucked 16 km south to the company's processing plant at Highwater. The mill produces high-quality floated material for use in the pulp and paper industry and dry-milled talc products for use as an industrial filler in paints and plastics. Soapstone is also produced and supplied as sculpture blocks. St-Lawrence Chemical Inc. is the sole distributor of all Bakertalc's products. By 1987, Bakertalc completed an expansion program which doubled its production capacity of high purity talc products, suitable for paper and plastic applications. The addition of its new pebble mill increased overall production capacity to more than 18 000 t/y.

LUZCAN Inc., near St-Pierre-de-Broughton, Quebec quarries two deposits associated with the Pennington dyke in Leeds and Thetford townships. Occurrences are associated with ultrabasic intrusives, periodotite-serpentinite, and in quartz-carbonate-chlorite schists. LUZCAN Inc. produces ground material containing nearly 70% talc, which is used as a filler in joint cement and auto-body compounds and as a dusting agent in asphalt roofing shingles and rubber products. The company also produces soapstone products such as refractory slabs and sculpture blocks. Since Talcs de Luzenac SA of France acquired a 50% equity position in B.S.Q. Talc Inc. to form LUZCAN Inc. a new processing plant was inaugurated. The plant's production capacity is about 40 000 t/y, which can easily be expanded to 60 000 t/y should market demand so permit. LUZCAN Inc., benefitting from the technical expertise of Talcs de Luzenac, now produces both talc-carbonate and talc-chlorite products. These products are suitable for paint, flooring and plastic products.

International Larder Minerals Inc. is currently developing the old Harvey Hill copper mine near Thetford Mines, Quebec. The company invested $920 000 for the rehabilitation of the mine in order to produce talc from proven reserves estimated at 4 Mt, and for working capital purposes. The processing plant will have a capacity of 40 000 t/y of high-quality talc to serve markets in paint, roofing products, rubber and ceramics in Quebec and eastern Canada by mid-1988.

In 1987, Carey Canada Inc. announced its discovery of a large, high grade talc deposit located on farm land between the towns of Leeds Station and East Broughton, Quebec. Diamond drilling results indicate that the deposit contains 8 Mt of possible ore grading 78-80% talc. About half of this tonnage would require no stripping, while the remaining 4 Mt would require limited stripping. Processing through flotation cells and a micronizer, which pulverizes the ore to -2 microns, indicate recoveries of 85 to 90%. Metallurgical testing shows no associated asbestos, while calcite and dolomite occur in quantities of less than one percent.

In Ontario, Commercial Industrial Minerals Limited, a subsidiary of Ram Petroleums Limited which holds mining leases on a large talc-tremollite deposit near Robertsville, made modifications to milling facilities located at Clarendon for the production of a wide variety of industrial minerals. The primary product will be tremolite and shipments of the mineral began in 1986. Reserves have been estimated at 2 000 000 t of tremolite and 350 000 t of talc.

Pyrophyllite

Newfoundland Minerals Limited, a subsidiary of American Olean Tile Company, Inc. (a division of National Gypsum Company), mines pyrophyllite from an open-pit operation near Manuels, 19 km southwest of St. John's, Newfoundland. The deposit appears to be a hydrothermal alteration of sheared rhyolite, associated mainly with extensive fracturing near intrusive granite contacts. Reserves are believed to be sufficient for 40 years at current levels of production. The ore is crushed, sized and hand-cobbed at the mine site. Production capacity is about 65 000 t/y. The high quality crude ore (a pyrophyllite-quartz product with minor sericite) is shipped to its parent's ceramic floor and wall tiles plants located in the United States where it is finely ground. Ceramic tiles produced by American Olean Tile Company, Inc. contain 60-70% pyrophyllite mixed with ground ball clay and flint. Some lower grade pyrophyllite has been used in the local manufacture of joint cement, paint and other products. The company is trying to develop markets for pyrophyllite with an alkali content in excess of 1.25% variable alumina.

Other known pyrophyllite deposits in Canada include an extensive area of impure pyrophyllite near Stroud's Pond in the southern part of the Burin Peninsula, Newfoundland; deposits in British Columbia, near Ashcroft and on Vancouver Island; and, near Senneterre, Quebec.

WORLD DEVELOPMENTS

In 1986, world production of talc and pyrophyllite decreased by 1.5% to 7.7 Mt. Asia accounted for over 57% of this production, followed by North America with 17%, western Europe with 15% and South America with 6%. The four leading producer countries of talc in the western world are the United States, Brazil, Finland and India. Japan is by far the leading producer country of pyrophyllite, followed by producers from South Korea, the United States and India.

United States

In the United States domestic shipments of talc increased by 6.7% in 1986 to 892 000 t, while domestic shipments of pyrophyllite fell by 6.5% to 105 000 t over the same period. The end-use distribution of ground talc sold in the United States was ceramics, 35%; paint, 17%; paper, 13%; roofing, 11%; plastics, 7%; and others, 17%. Pyrophyllite sales in 1986 were broken down as follows: ceramics, 55%; refractories, 17%; insecticides, 11%; and others, 17%.

Talc was produced at 34 mines, located in nine states. Total U.S. production of talc and pyrophyllite was 1.18 Mt in 1986, with a total value of $31 227 000.

The Montana Talc Co., a joint venture between NICOR Mineral Ventures and Meridian Land and Minerals Co., began operating its mine and mill near Ennis, Mt. Following a legal dispute, NICOR Minerals Ventures sold its interest in Montana Talc Co. to Costain Holdings Inc.

Both Pfizer Inc. and Cyprus Industrial Minerals Company shut down their California operations in 1986 and 1987, respectively. Cyprus Industrial Minerals Company obtained mineral rights to a talc deposit located near Alpine, Alabama and is currently developing the property with the intention that this mine will feed its Alpine plant.

Subsequent to Acqui-Talc Inc.'s merger with Vermont Talc, division of Omya Inc., the mill at Johnson, Vt. was upgraded and new milling equipment was installed. A new deposit located near Troy, Vt. is being developed for future supply to the Johnson plant.

The three most important producers of pyrophyllite in the United States are located in North Carolina. There is a small mining operation in California that operates on an intermittent basis.

Finland

In Finland, Finnminerals Oy dominates talc production with its mines located at Sotkamo and Polvijarvi, and its plants located at Sotkamo and Outokumpu. The company's total production capacity approaches 360 000 t/y, and 1986 production was in the order of 230-250 000 t.

Myllykoski Oy operates two open pit mines in Polyjarvi and Kajaani with 1986 output estimated to be approximately 90 000 t, destined primarily for European pulp and paper mills.

Finland exports its talc products primarily to Sweden, Denmark, Germany, Great Britain and Belgium-Luxembourg. Finish talc producers are favoured suppliers to eastern Europe with annual exports to the U.S.S.R. varying between 6-11 000 t.

United Kingdom

Nortalc Milling Ltd., a subsidiary of A/S Norwegian Talc, announced its intentions to establish a talc and dolomite grinding operation at Hartlepoole, U.K. in 1986. The plant will be supplied with the company's Norwegian ore.

Shetland Talc Ltd., a joint venture between Dalriada Mineral Ventures Ltd. and Anglo-European Minerals Ltd., is currently testing talc from its deposit located at Cunningsburgh in the Shetland Islands. Test results indicate that the deposit with several million tonnes of talc-magnesite contains between 55-60% talc. Plans are to establish a 30-35 000 t/y plant.

France

Talcs de Luzenac SA is the dominant talc supplier to western Europe and in the last few years has been engaged in expanding its supplier position to include North America. Talcs de Luzenac SA has a mine and processing plant in Luzenac, France. Talcs de Luzenac SA also has operations in Austria

(Talkumwerke Naintsch GmbH, 80%), Italy (Mineraria Valle Splurga Srl., 77%) and in Spain (Talcos Pyrenaicos SA, 49%). Recent acquisitions include LUZCAN Inc. (50%) and U.S. American French Talc Inc. (100%). In 1986, Talcs de Luzenac's talc production from its French operations is estimated to be 330 000 t.

Italy

In 1986, Italy produced 151 000 t of talc and steatite, up 16% from 1985. The leading Italian producer is Talco e Grafite Val Chisone SpA, with about a 50-60% share of production. Mineraria Valle Splurga Srl, a subsidiary of Talcs de Luzenac of France, is Italy's second leading talc producer. In February 1986 Valle Splurga began operations at its new mine in Valmalenco and now has a mine capacity of 80 000 t/y. The processing plant located at Sondrio has expanded its capacity in 1986 to 60 000 t/y.

Industria Mineraria Italiana operates two mines, the Santalla mine at Lanzada and Pra Mosin mine at Torre Santa Maria, with total mine capacity of 72 000 t/y. Industria Mineraria Italiana recently announced that it intends to develop a new talc/steatite mine at Le Prese and to upgrade its 55 000 t/y plant at Torre Santa Maria.

Australia

In 1986, Australia produced an estimated 250 000 t of talc, steatite and pyrophyllite. The Three Springs talc mining operation, Australia's largest, was taken over by Western Mining Corporation Limited. The operation which produced approximately 160 000 t in 1986 was previously a 50/50 joint venture between Western Mining Corporation Limited and Kalgoorlie Southern Gold Mines Ltd. (KSGM).

USES AND SPECIFICATIONS

Talc is an extremely versatile mineral and is used primarily in a fine-ground state, while soapstone is used in massive or block form. There are many industrial applications of ground talc, although fewer than a dozen countries use talc on a major scale.

In pulp and paper manufacture, softness, chemical inertness, high reflectance, hydrophobic and organophilic properties and the particle shape of talc, are characteristics that permit its use as a pitch control agent, as a paper filler and as a coating pigment. For filler applications, maximum particle size should not exceed 20 microns, although 40 micron grades are also used. As a coater, talc particle size must not exceed 10 microns and as a pitch control agent, it should be as close to 1 micron as possible.

The ceramic industry utilizes very finely ground talc to increase the translucence and toughness of the finished product and to aid in promoting crack-free glazing. Talc must be low in iron, manganese and other impurities which would discolour the fired product. Average particle size for talc used for most ceramics must range between 6 and 14 microns, with 90-98% of material passing through 45 microns.

In plastics, talc improves dimensional stability, chemical and heat resistance, impact and tensile strength, and electrical and insulation properties. Talc is used in both thermoplastics and thermosets, primarily in polypropolene, nylon and polyester. Chemical coupling agents are used to enhance the bond between the talc filler and the resin matrix in plastic materials. The mineral must be free of iron impurities and grits, and must be superfine with an average particled size below 8 microns.

The paint industry uses high-quality talc as an extender pigment. A low carbonate content, a near white colour, a fine particle size with controlled size distribution and a specific oil absorption are important. However, due to the variety of paints, precise technical requirements for talc pigments are agreed on between consumers and suppliers. Paint characteristics which influence the use of talc as an extender pigment are gloss, adhesion, flow, hardness and hiding power.

Pharmaceutical industries are well-established users of high-purity talc for preparations and cosmetics because of its softness, hydrophobic property and chemical inertness. When finely ground this talc grade is used as a filler in tablets and as an additive in medical pastes, creams and soaps.

Lower grade talc is used as a dusting agent for asphalt roofing and rubber products, as a filler in drywall sealing compounds, floor tiles, asphalt pipeline enamels, auto-body patching compounds, and as a carrier for insecticides. Other applications include cleaning compounds, polishes, electric cable coating, foundry facings, adhesives, linoleum textiles and in the food industry.

Soapstone, today, has only limited use as a refractory brick or block; however, its softness and resistance to heat permits its use in marking crayons for metalworkers. Also, the ease with which it can be carved makes soapstone an excellent artistic medium.

Pyrophyllite can be ground and used in much the same way as talc. In ceramics, it imparts a very low coefficient of thermal expansion to tiles. The product must be ground to minus 45 microns and must contain minimal amounts of quartz and sericite as impurities. Pyrophyllite may also be used in refractories because its expansion on heating tends to counteract the shrinkage of the plastic fraction. This is particularly true of massive pyrophyllite, the compact and homogenous variety, although small amounts of the crystalline or radiating variety may also be used. Foliated or micaceous pyrophyllite is used as a filler and ceramic raw material.

PRICES

Talc prices vary according to quality, method of processing, specifications and transportation costs. While most American and Canadian list prices for talc have not changed in the past two years, the Canadian actual average talc price has risen 8.3% in 1987. Over the last three years Canadian talc prices have risen steadily, reflecting both increases in demand from Canadian and U.S. consumers, and a shift towards higher-quality talc products.

List prices for ceramic and filler grade pyrophyllite vary between US$35-45 per t for bulk material, f.o.b. plant, while refractory grade list prices vary between US$25-35 per t.

OUTLOOK

North American talc production capacity of approximately 1.5 to 1.8 Mt exceeds current North American demand of 1.1 Mt. While talc markets are expected to grow faster than the economy as a whole over the short-term, the industry's excess capacity situation is expected to persist to the end of the decade.

Both talc and pyrophyllite find their greatest market acceptance in the production of ceramic products. More specifically, talc is used in applications such as floor and wall tile, earthenware, sanitaryware, stoneware and in electrical ceramics. The expected demand for these ceramic products, as in the past, will grow much faster than the economy as a whole. The North American gross national product is forecast to grow at an annual rate between 2.5 and 3.5% for the next two years. However, due to health concerns regarding the tremolitic content of some talcs used in these applications and the potential substitution towards feldspar, growth in talc consumption by the ceramics industry is not expected to be greater than 4% per annum.

The paint and roofing products industries are the next two largest consumers of talc. These industries future prospects are considered to be tied to the construction industries, which are expected to grow in the same order of 2.5 to 3.5% per annum. As no knew substitutes seem to be emerging, talc consumption by the paint and roofing products industries is expected to grow annually by 3-4%.

The paper industry is increasingly replacing expensive wood fibre with relatively cheap industrial mineral fillers and coaters such as talc; therefore high annual growth in talc consumption of 7% per annum is forecast in this sector.

Demand for talc and other mineral fillers as a reinforcement filler in plastic applications over the last decade has been growing in excess of 6% per annum. This good performance is expected to continue in the longer term. However, the growth in consumption of chemically-modified talc used in plastics will be dependent largely on the production of polypropylene. Surface-treated talc is expected to grow more rapidly than untreated talc.

North American consumption of pyrophyllite is in the order of 100 000-120 000 t/y, of which about 60 000 t is used in ceramics and 20 000 t in refractories. In North America and western Europe consumption of pyrophyllite in ceramics is expected to grow at about 1% a year until the year 2000, mainly because substitutes such as low quality talc and clays are available at low costs in many countries. Consumption of pyrophyllite in refractories should grow at a low rate of 1 to 2% due to the trend toward using more efficient and more readily available high alumina and high magnesia refractories.

PRICES

Talc; free on board mine, carload lots, containers included unless otherwise specified: US$ per short ton.

	1987
New Jersey	
mineral pulp, ground; (bags extra)	18.50-20.50
Vermont	
98% through 325 mesh, bulk	70
99.99% through 325 mesh, dry processed, bags	147
99.99% through 325 mesh, water beneficiated, bags	213-228
New York	
96% through 200 mesh	67-75
98-99.25% through 325 mesh (fluid energy ground)	83-100
100% through 325 mesh (fluid energy ground)	165
California	
Standard	130
Fractionated	37-71
Micronized	150-220
Cosmetic/Steatite	44-65
Georgia	
98% through 200 mesh	50
99% through 325 mesh	60
100% through 325 mesh (fluid energy ground)	100

Source: Engineering and Mining Journal, 1987.

Pyrophyllite; free on board, bulk: US$ per metric tonne.

	1987
Australia	
refractory grades	25-35
ceramic and filler grades	35-45
United States	
min.20 s.t.; for lots exports	80-92

Source: Industrial Minerals, 1987.

TABLE 1. TALC, SOAPSTONE AND PYROPHYLLITE PRODUCTION, TRADE 1985-87 AND CONSUMPTION 1985 AND 1986

	1985		1986		1987P	
	(tonnes)	($)	(tonnes)	($)	(tonnes)	($)
Production (shipments)						
Talc and soapstone						
Quebec[1]	..	3 143 876	..	3 192 349	..	2 975 600
Ontario[2]	..	8 474 604	..	9 643 946	..	11 475 650
Total	..	11 618 480	..	14 438 000	..	14 451 250
Pyrophyllite						
Newfoundland	..	1 733 765	..	1 345 989	..	1 668 210
Total production	126 860	13 352 248	123 037	14 182 284	141 223	16 119 460
					(Jan.-Sept.)	
Imports		($000)		($000)		($000)
Talc, incl. micronized						
United States	40 213	8 493	38 310	8 298	35 925	6 275
United Kingdom	49	7	135	17	129	16
Italy	29	3	4	1	86	11
France	91	35	295	61	51	15
Japan	29	3	0	0	0	0
Other	54	4	1	..	5	14
Sub-total, talc	40 466	8 565	38 745	8 377	36 196	6 331
Soapstone, exc. slabs						
Finland	0	0	1	..	218	28
United States	68	10	24	2	78	11
Sub-total, soapstone	68	10	24	3	296	39
Pyrophyllite						
United States	598	45	624	49	484	44
Sub-total, pyrophyllite	598	45	624	49	484	44
Total talc, soapstone and pyrophyllite	41 132	8 620	39 393	8 429	36 976	6 414

	1985	1986P
	(tonnes)	
Reported Consumption[3] (ground talc, available data)		
Pulp and paper products	24 005	23 731
Asphalt roofing products	19 114	20 189
Paint and varnish	6 857	7 681
Ceramic products	2 575	2 658
Rubber products	3 676	1 762
Toilet preparations	1 723	1 496
Other products[4]	6 824	7 120
Total	64 774	64 640

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Ground talc, soapstone, blocks and crayons. [2] Ground talc. [3] Reported from EMR survey on the consumption of nonmetallic minerals by Canadian manufacturing plants. [4] Fertilizers, adhesives, cleaners, bearings and brake linings, refractories and other miscellaneous uses.
P Preliminary; .. Not available.

TABLE 2. CANADA, TALC AND PYROPHYLLITE PRODUCTION AND IMPORTS, 1970, 1975, AND 1980-87

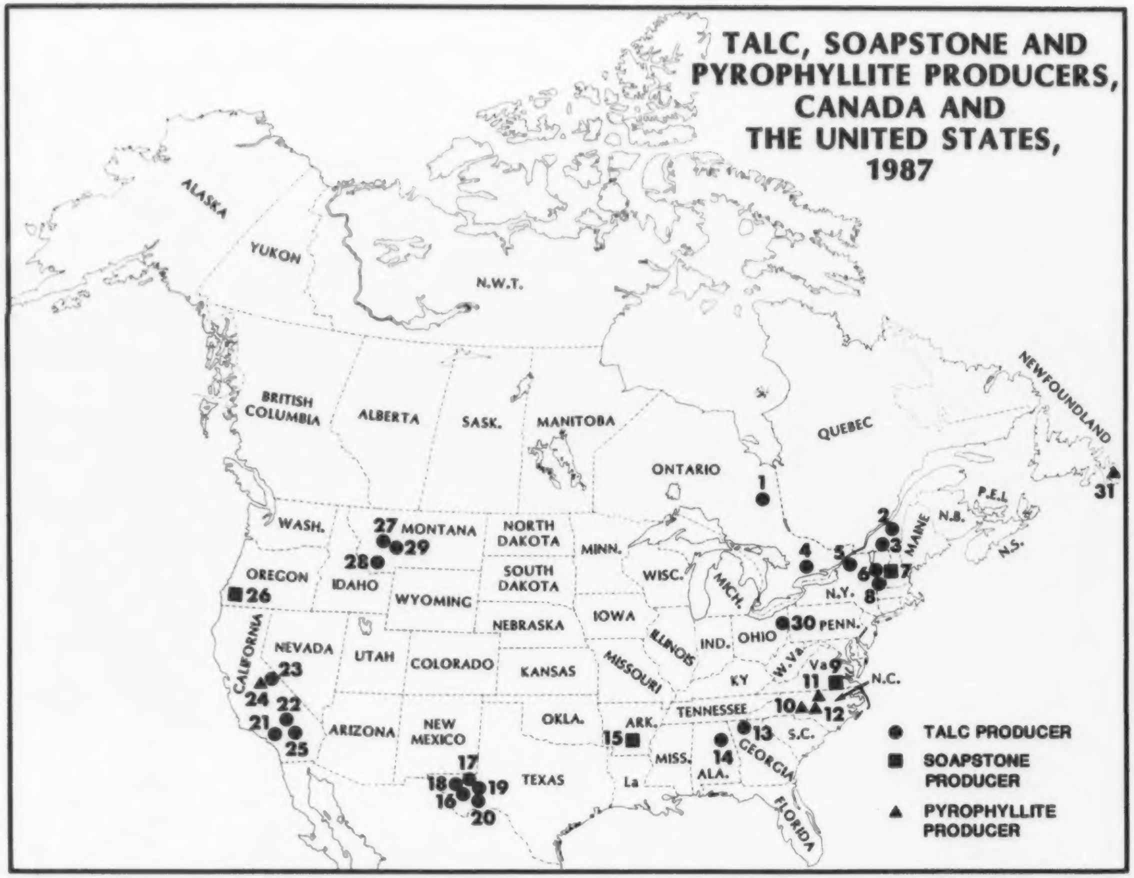
	Production[1]	Imports
	(tonnes)	
1970	65 367	29 999
1975	66 029	30 428
1980	91 848	50 774
1981	82 715	30 322
1982	70 523	34 522
1983	97 030	35 406
1984	122 992	38 817
1985	126 860	41 132
1986	123 037	39 396
1987P	141 223	..

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Producers' shipments.
P Preliminary; .. Not available.

TABLE 3. WORLD PRODUCTION OF TALC, SOAPSTONE AND PYROPHYLLITE, 1982-86

	1982	1983	1984[r]	1985	1986[e]
			(000 tonnes)		
Japan	1 492	1 466	1 499	1 434	1 334
United States	1 030	967	1 023	1 151	1 181
People's Republic of China[e]	952	952	953	998	998
Republic of Korea	591	632	849	932	900
U.S.S.R.[e]	510	510	517	517	517
Brazil	384	454	413	425	425
India	336	353	418	383	380
Finland	325	318	327	330	330
France	277	285	292	311	320
Australia	152	150	241	250	250
North Korea	168	168	168	168	168
Italy	164	158	143	130	151
Norway	85	87	143	150	150
Canada	70	97	127	123	141
Austria	117	121	134	131	120
Other countries	385	357	369	424	372
Total	7 038	7 075	7 616	7 857	7 737

Sources: U.S. Bureau of Mines, Talc and Pyrophyllite 1986; Energy, Mines and Resources Canada.
[e] Estimated; [r] Revised.



TALC, SOAPSTONE AND PYROPHYLLITE PRODUCERS, CANADA AND THE UNITED STATES, 1987

ALASKA
YUKON
N.W.T.
BRITISH COLUMBIA
ALBERTA
SASK.
MANITOBA
ONTARIO
QUEBEC
NEWFOUNDLAND
P.E.I.
N.B.
N.S.
WASH.
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
ARIZONA
COLORADO
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLA.
TEXAS
MINN.
IOWA
MISSOURI
ARK.
La
WISC.
ILLINOIS
MICH.
IND.
OHIO
KY
TENNESSEE
MISS.
ALA.
GEORGIA
FLORIDA
S.C.
N.C.
Va
W.Va
PENN.
N.Y.
MAINE
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● TALC PRODUCER
■ SOAPSTONE PRODUCER
▲ PYROPHYLLITE PRODUCER

	Company	Parent Corporation	Production Capacity	Remarks
1.	Steetley Talc Inc.	Steetley Industries Limited	55-64 000	- full line of products
2.	LUZCAN Inc.	Talcs de Luzenac SA	40 000	- joint cements, asphalt roofing, rubber
3.	Bakertalc Inc.	-	18 000	- paper, joint compounds, paint
4.	Canada Talc Limited	William R. Barnes Co.	55 000	- paint, adhesives, plastics, ceramics
5.	Gouverneur Talc Co. Inc.	R.T. Vanderbilt Co. Inc.	230 000	- ceramics, paint and paper
6.	Windsor Minerals Inc.	Johnson & Johnson	225 000	- joint compounds, rubber, asphalt roofing, plastics
7.	Vermont Soapstone Co. Ltd.	-	N.A.	
8.	Vermont Talc	Omya Inc.	100 000	- full line of products, excluding ceramics
9.	Blue Ridge Talc Co. Inc.	-	N.A.	
10.	Glendon Pyrophyllite Co.	-	200 000	- joint compounds, refractories
11.	Piedmont Minerals Co. Inc.	Resco Products Inc.	85 000	- porcelain, refractories, plastics
12.	Standard Mineral Co. Inc.	R.T. Vanderbilt Co. Inc.	50 000	- ceramics, paint
13.	Southern Talc Co.	United Catalysts Inc.	47 000	- asphalt coating, insecticide
14.	Cyprus Industrial Minerals Company	Cyprus Minerals Company	N.A.	- fed by Montana mines
15.	The Milwhite Co., Inc.	-	N.A.	
16.	Southern Clay Products Inc.	ECC America Inc.	90 000	- ceramics
17.	Westex Minerals Co.	The Milwhite Co. Inc.	30 000	- wall tile, off-white filler
18.	Pioneer Talc Co.	Whittaker, Clark & Daniels	50 000	- wall tile, off-white filler
19.	Apache Minerals Inc.	-	N.A.	
20.	Texas Talc Inc.	Dal-Til	25 000	- wall tile
21.	Cyprus Industrial Minerals Company	Cyprus Minerals Company	25 000	- ceramics
22.	Pfizer Inc.	-	90 000	- ceramics
23.	Standard Industrial Minerals Inc.	Standard Slag Co.	1 000	- pharmaceuticals and cosmetics
24.	Standard Slag Co.	-	N.A.	
25.	Huntington Tile, Inc.	-	N.A.	
26.	Steatite of Southern Oregon	-	500	- steatite blocks
27.	Cyprus Industrial Minerals Company	Cyprus Minerals Company	150 000	- full line of products
28.	Pfizer Inc.	-	135 000	- full line of products
29.	Montana Talc Co.	Meridian Land and Minerals Co. and Costain Holdings Inc.	36 000	- pulp and paper
30.	U.S. American French Talc Inc.	Talcs de Luzenac SA	15 000	- fed from European mines
31.	Newfoundland Minerals Limited	American Olean Tile Company, Inc.	65 000	- ceramics

N.A. Not available.

Tantalum[1]

D.G. FONG

Tantalum Mining Corporation of Canada Limited (TANCO) announced that it will resume production of tantalum concentrates at its Bernic Lake, Manitoba mine in July 1988. Tantalum production had been suspended since the end of 1982 because of weak markets. However, the company modified the tantalum plant at a later date and used it to produce ceramic-grade spodumene concentrate. The decision to resume tantalum operations was made possible as a result of gradual recovery in tantalum markets and the company's recent signing of long term contracts with a number of processors. The long term contracts will guarantee a market for TANCO tantalum into 1992.

TANCO plans to spend $4.7 million to refurbish the mine and mill, and to complete the installation of the spodumene plant that was started in 1986. The reopening of the tantalum plant will require the company to complete the spodumene plant in order to run both operations at the same time. When the mine and associated plants are fully operational, they will be capable of producing about 109 t of tantalum contained in concentrate and about 15 000 t of spodumene concentrate a year.

TANCO is jointly owned by Hudson Bay Mining and Smelting Co., Limited (37.5%), Cabot Berylco Inc. (37.5%) and the Manitoba government (25%).

The TANCO list price for tantalite remained suspended in 1987. The Metals Week spot price for tantalite increased gradually from US$40.79-50.71/kg contained Ta_2O_5 at the beginning of the year to US$52.91-61.73 at year-end because of a steady increase in demand and a significant decline in inventories.

OUTLOOK

The tantalum market is expected to continue to improve in 1988, and western world mine production will be significantly higher in order to satisfy demand. Although inventories had been high, these are forecasted to reach normal levels by mid-1988.

Future supply will be more dependent on an increase in mine concentrates than tantalum bearing slags from tin smelting. The tin industry is expected to continue to be plagued by low prices in the aftermath of the 1985 tin crisis and, accordingly, tantalum from this source will be suppressed.

The main supply increase will initially come from Canada and Brazil. TANCO is scheduled to restart its tantalum mining by mid-1988 and Paranapenema SA in Brazil has announced plans to recover tantalum and columbium oxides from its Pitonga tin mine in the Amazon region in 1988. Greenbushes Tin Ltd. in Australia has yet to announce its production plan. However, with large proven reserves and further mine expansions as its long term goal, Greenbushes could make Australia the largest tantalum producer in the world during the next decade.

The concentrate market looks especially promising because a significant part of incremental supplies will be in the form of intermediate products. The new Brazilian recovery plant is scheduled to produce oxides and the Australian producer has been diversifying into oxides, carbides and metals. In addition, Thailand Tantalum Industry Corporation has announced its intention to rebuild the tantalum plant that was destroyed in a fire in 1986. The startup of the Thailand plant will significantly reduce the availability of tantalum bearing tin slags to processors. Thailand was the largest supplier of tantalum feedstocks prior to the tin crisis.

The generally favourable economic conditions that are projected for several years should result in a strong demand for

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[1] This review is an update of 1987 developments and forecasts. For additional information on tantalum, the reader is referred to the 1983-84 edition of the Canadian Minerals Yearbook.

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electronic capacitors and superalloys. The market for electronic capacitors, which accounts for over 50% of tantalum consumption, is forecasted to increase 5-10% a year over the next five years. However, the growth in demand for tantalum will be significantly less because the use of high-charge powders and the miniaturization of capacitors will substantially reduce the requirement on a per unit capacitor basis.

Tantalum bearing superalloys are used mainly in jet engines. Such superalloys contain up to 12% tantalum and have a specific application as heat-resistant single-crystal turbine components. Although this accounts for only 10% of total consumption, it is a growing market and the trend is expected to continue. In the carbide market, extensive substitution of tantalum, due to high tantalum prices of the late 1970s, has now stabilized. However, technological improvements in tool design and downsizing of machined components could lead to a lower demand for carbides in metal cutting tools.

Overall, the industry is likely to be much more stable in the coming years than in the past decade when it was undergoing major structural changes. With global supply and demand expected to be balanced by late-1988 or early-1989, mine producers should be able to plan their production schedules with more certainty. TANCO could be the leading beneficiary because of the strong market for tantalum concentrates, its long-term contracts and the added advantage of operating a spodumene circuit.

PRICES

Prices as quoted in Metals Week in December 1986 and 1987, U.S. currency.

	1986	1987
	($)	
Tantalum ore		
Tantalite, per kg of pentoxide, Tanco price	List price suspended	
Spot tantalite ore, per kg of pentoxide	40.79-50.71	52.91-61.73

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
				(%)	
CANADA					
32900-1	Columbium and tantalum ores and concentrates	free	free	free	free
35120-1	Columbium (niobium) and tantalum metal and alloys in powder, pellets, scrap, ingots, sheets, plates, strips, bars, rods, tubing or wire for use in Canadian manufactures (expires June 30, 1987)	free	free	25	free
37506-1	Ferrocolumbium, ferrotantalum, ferro-tantalum-columbium	free	4.0	5	free
UNITED STATES					
601.42	Tantalum ore		free		
629.05	Tantalum metal, unwrought and waste and scrap		3.7		
629.07	Tantalum, unwrought alloys		4.9		
629.10	Tantalum metal, wrought		5.5		

Sources: The Customs Tariff, 1987, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1987), USITC Publication 1910; U.S. Federal Register, Vol. 44, No. 241.

TABLE 1. CANADA, TANTALUM PRODUCTION, TRADE AND CONSUMPTION, 1970, 1975 AND 1980-87

	Production[1]	Imports[2]		Consumption
		Primary forms and fabricated metals		
	Ta_2O_5 Content	Tantalum	Tantalum Alloys	Ferrocolumbium and Ferro-tantalum-columbium, Cb and Ta-Cb Content
	(kilograms)			
1970	143 800	..	..	132 449
1975	178 304	..	..	215 910
1980	115 261	21 280	12 112	486 251
1981	103 949	2 769	5 043^r	455 500
1982	59 276	1 759	1 146	356 000
1983	-	1 742	332	359 000
1984	-	4 489	1 499	482 000
1985	39 457	2 370	1 354	447 000
1986	38 846	2 137	1 918	438 000P
1987P	36 300	16 318	303	..

Sources: Energy, Mines and Resources Canada; Statistics Canada; U.S. Department of Commerce.

[1] Producers' shipments of tantalum ores and concentrates and primary products, Ta_2O_5 content. [2] 1987 imports based on eleven month statistics.

P Preliminary; - Nil; .. Not available; ^{r} Revised.

Tin

A. BOURASSA

Tin prices were remarkably stable in U.S. dollars throughout 1987 but drifted slowly downward in Europe and Japan where they fell close to the lowest levels reached in the summer of 1986. Tin mine production has responded to the low price and the supply-demand balance showed a deficit. The deficit is, however, less than had been predicted because of rapidly increasing exports of concentrate and metal from China. Metal consumption has not so far responded to lower prices and is basically stable. The Sixth International Tin Agreement was extended for two years to July 1989, and will not be renewed thereafter. UNCTAD is expected to sponsor resumed negotiations in 1988 on the formation of an International Tin Study Group.

CANADIAN DEVELOPMENTS

Canada's only primary tin price opened by Rio Algom Limited near East Kemptville, N.S., in 1985. After the company wrote off its investment in the mine in 1986, its ownership reverted to the consortium of creditor banks, led by Bank of America (Canada). The consortium operated the mine throughout 1987 and continued investments needed to improve recovery at the mill. Production of tin in concentrate for 1987 is estimated at 3 397 t. At year-end, it was announced that Rio Algom and the banks had signed a letter of intent confirming Rio's interest in repurchasing the mine. A final agreement should be signed by late February 1988. Most of the concentrate produced at the mine in 1987 was smelted at the Capper Pass & Son Ltd. smelter in the U.K., which is owned by Rio Algom's parent.

The East Kemptville orebody is estimated to contain 56 Mt grading 0.16% tin, to be recovered by open-pit mining. Mill capacity is 9 000 t/d. Project life expectancy would see the mine operating somewhat beyond the turn of the century. East Kemptville is now the only producer of tin concentrate in Canada. Tin by-product recovery by Kidd Creek Mines Ltd. at Timmins, Ont. and Cominco Ltd. at Kimberley, B.C. has been discontinued. Tin mineralization is known in various parts of Canada and higher prices until 1985 had encouraged exploration. The East Kemptville deposit was the first major discovery, although other deposits are known across the country. Lac Minerals Ltd. has completed a research and exploration project on the North Zone tin prospect at Mount Pleasant, N.B. after spending more than $6 million. A feasibility study is now under way and should be completed early in the spring of 1988. A decision whether to pursue this project further could be made by mid-1988. Lac Minerals also acquired an option to earn 50% in the property owned by Billiton N.V. Previous drilling had indicated 5.1 Mt of potential reserves grading 0.79% tin.

Canada relies on imports for its tin metal requirements except for small amounts recovered from recycled solders and detinning, and in primary tin-lead alloys production. Consumption has been falling for several years but this trend was reversed in 1984 when imports grew by almost 20%. Increased consumption was especially noteworthy in tin plate produced by two large Canadian steelmakers, Stelco Inc. and Dofasco Inc. Using metal imports as an indicator of the trend in domestic consumption, it appears that consumption may have dropped marginally in 1987.

WORLD DEVELOPMENTS

Since 1973, world tin consumption has trended downward because of substitution away from tin in some end uses, and technological developments that have decreased the quantities of tin required in the making of some tin products. This trend was reversed in 1984, mostly as a result of the worldwide economic recovery, but structural factors that caused the previous decline are still present. However, consumption may now stabilise around present levels due to the growth potential of some tin uses and lower future tin prices which should reduce pressure for substituting away from tin.

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As can be seen from Table 4, low tin prices in both 1986 and 1987 have not had a notable impact on overall tin consumption. Tin concentrate production in the non-socialist world dropped in 1987. The Association of Tin Producing Countries (ATPC) has established export quotas for its members in order to limit production, accelerate the absorption of the tin stock overhang and bring about better prices. It has yet to be demonstrated that these quotas were the major reason for falling production in these countries. Low prices probably had more impact and several countries did not fill their quotas. Members' export quotas for 1987 totalled 96 000 t while production was around 90 000 t. Total exports were therefore even lower. Production of primary tin metal was roughly the same in 1987 as in 1986.

Statistics in the accompanying tables do not include information on most centrally planned countries. Leading producers among these countries include the U.S.S.R. and the People's Republic of China, for which the United States Bureau of Mines estimates production at 23 000 t and 15 000 t, respectively. The Democratic Republic of Germany is estimated to have produced 1 800 t. Tin from these countries is generally consumed domestically, although China is a net exporter to the west (estimated at 11 000 t in 1987). The combined net imports of the U.S.S.R. and East Germany from the west are estimated at about 14 400 t in 1986.

The removal of export controls by the International Tin Council (ITC), efforts by governments to reduce and in some cases eliminate taxes and royalties on tin mine production, and low tin prices have brought a marked decline in concentrate smuggling. Tin smuggling in southeast Asia had become a major factor, accounting for an estimated 7% of total production or 11 000 t in 1985. While a precise figure on current smuggling cannot be established, it is believed not to exceed 1 000 t/y.

The United States General Services Administration (GSA) continued sales of tin from the strategic stockpile. Sales in 1987 were about 4 080 t. The goal for the United States strategic stockpile is 42 700 t, compared to holdings of about 176 000 t at the end of 1987. Although GSA sales represent only a small percentage of the total market, producers believe that they contribute to downward pressure on prices, especially under the current unfavourable circumstances. Sales for 1988 are forecasted at about the same level as in 1987.

It is becoming increasingly clear that traditional tin producers, especially Malaysia but also Bolivia, Indonesia and Thailand, are losing control over the tin market. They are producing an ever decreasing share of world production as other major suppliers such as Brazil and China are emerging. As a country, Brazil is probably the lowest cost producer. Although it has been cooperating with ATPC in restraining its exports, Brazilian producers do not support a return to the very high price levels of 1985. Moreover, they have the capability of increasing production to restrain prices should they judge it necessary. Most observers had anticipated a supply deficit in the order of 30 000 t for 1987 but it now appears that the real figure may be under 20 000 t. One of the major reasons for this reduced deficit is Chinese exports of concentrate and metal.

In Australia, 1987 saw the closure in September of the last significant producer in Queensland - Great Northern Mining Corp. NL - which had been producing about 200 t/y. The Queensland output is now limited to a few tonnes of tin from small alluvial operations. This leaves two main producers. Renison Ltd. produced about 6 500 t in 1987. The concentrate is exported to Malaysia for smelting. Greenbushes Tin Ltd. produced about 500 t. The concentrate is treated in the company's smelter. The Tolltrec smelter in Sydney is not operating because of a lack of concentrate.

Bolivia's mining industry is now being restructured and the government is considering new laws to make foreign investment in mining more attractive. Tin production dropped substantially again in 1987, to about 8 000 t. It may be some time before the situation improves but production has now probably bottomed out.

Brazil is the world's lowest cost tin producer. That is true especially for its largest tin company, Paranapanema SA. The company produced just under 20 000 t of tin in concentrate in 1987. Production costs at the Pitinga alluvial operation are estimated at US$1.60/lb. The company has announced that it will increase production to whatever level is necessary to prevent prices from exceeding US$8200/t ($3.72/lb). The company will soon start extracting ore from a primary deposit in the Pitinga area. This tin orebody also contains niobium, tantalum, zirconium and yttrium. However, not all Brazilian tin companies are low cost producers. The third largest producer, Empresas Brumadinho, filed for receivership in December. The company had been having difficulties since 1984 when it decided to go ahead with its tin project in Goias. Brazilian tin production in 1988 should be at about the same level as in 1987, assuming Brumadinho's operations are maintained.

Very little information is available on China's tin industry. It is known to be expanding, particularly in the Dachang area of the Zhuan autonomous region and also in Yunnan province. As well, a new smelter has opened in Guangxi. These may be events underlying China's strong showing in 1987 when it increased its exports of concentrate and metal by about 9 000 t of metal equivalent.

Indonesian production is increasing steadily and exceeded 26 000 t in 1987. The state company, P.T. Tambang Timah, is now producing about 20 000 t/y of tin in concentrate, while P.T. Koba Tin is producing close to 4 000 t/y. A new company, P.T. Preussag Kelapa Kampit, is producing under 1 000 t/y.

Malaysia's concentrate production rose slightly in 1987. It remains the largest tin producing country, but Indonesia and Brazil are closing fast and are generally lower cost producers. The Malaysian industry is also much more fragmented. Unless tin prices increase substantially in the future, the industry may have to further rationalize and consolidate in order to meet growing competition. The Kuala Lumpur commodity exchange started trading in tin futures in 1987 but business has been very slow as the exchange is not centrally located for major traders.

The Nigerian industry has apparently shut down but it is unclear whether suspension of operations is temporary or permanent.

Thailand's tin industry has been badly hit by the drop in tin prices and its production fell again in 1987. Production has probably bottomed out, however.

INTERNATIONAL ORGANIZATIONS

The International Tin Agreement

Tin is the only metal for which there is an agreement involving producing and consuming countries that contains economic provisions for market stabilization. Successive five-year pacts have been in force since 1956. The Sixth International Tin Agreement entered provisionally into force on July 1, 1982, to replace the Fifth Agreement. Provision is made in the agreements for market stabilization measures, including purchases and sales under a buffer stock arrangement, and the implementation of export controls on producing members if buffer stock operations are insufficient to protect the floor price.

Upon its entry into force, countries that had either signed or ratified the Sixth Agreement included six producers (Australia, Indonesia, Malaysia, Nigeria, Thailand and Zaire), which together accounted for 70% of reported 1982 world tin mine production, and 18 consuming members, including Canada, which together accounted for 51% of 1982 world tin consumption. Leading members of the Fifth Agreement that did not join the Sixth were the United States, U.S.S.R. and Bolivia. Brazil was never an International Tin Agreement member.

Association of Tin Producing Countries

The association was officially formed on August 13, 1983, after lengthy negotiations. It had five members: Bolivia, Malaysia, Indonesia, Thailand and Zaire. Nigeria joined on August 31 and Australia in November of the same year. The seven members account for about 70% of non-communist world tin production but Brazil participates in association meetings as an observer. The association's head office is in Kuala Lumpur, Malaysia and its initial objectives were the promotion of tin use through research and technological development, support of the Sixth ITA's market stabilization activities and an increase in the economic spinoffs from tin production in the economies of member countries.

The association works closely with the International Tin Research Council in London, England and the South East Asia Tin Research and Development Centre, in Malaysia. Both of these organizations are already financed by the same tin producers.

Research Organizations

The International Tin Research Council is entrusted with the task of maintaining and extending the use and effectiveness of tin in modern technology. It is financed by the governments of six of the major tin producing countries, Bolivia, Indonesia, Malaysia, Nigeria, Thailand and Zaire. Its headquarters and the International Tin Research Institute are in Greenford, Middlesex, England. The Council also has organizations for information, service and technical development in several major tin consumer and producer countries.

The South East Asia Tin Research and Development (SEATRAD) Centre is a regional organization established by the governments of Indonesia, Malaysia and Thailand, with assistance from the Economic and Social Commission for Asia and the Pacific (ECAP) and other United Nations agencies. The purpose of the Centre is to promote, conduct and coordinate research and training in relation to the technical and economic aspects of exploration, mining, mineral processing and smelting of tin. The Centre's headquarters and laboratories are located in Ipoh, Malaysia. In addition to the work being conducted in the laboratory, field projects are maintained in various member countries in southeast Asia. The Centre is financed by equal contributions from member countries.

International Tin Study Group

After members of the International Tin Council announced that they would not seek a Seventh International Tin Agreement, tin producing and consuming countries met in Geneva in November 1986, under the sponsorship of UNCTAD, to see whether there was sufficient interest in a continued consumer-producer cooperation on tin. The response from participants was generally favourable to continued cooperation through an International Tin Study Group. UNCTAD is now preparing for a first negotiating meeting for the formation of such a study group which should take place in Geneva early in 1988.

It is expected that the study group will be modelled on the International Nickel Study Group. It will be totally separate from the International Tin Council and will have no market intervention powers. Its purpose will be to enhance tin market transparency through comprehensive statistical data collection and dissemination and through appropriate market studies.

PRICES AND STOCKS

In equivalent U.S. dollars, tin prices were remarkably stable in 1987. They fluctuated only slightly around a $3.10/lb. average. The picture was somewhat different in European and Japanese currencies where prices by year end had fallen back to levels almost as low as in the summer of 1986.

The real level of tin stocks remains unclear. Tin metal supply for 1987 included 147 600 t of primary tin metal production, 4 080 t from the GSA stockpile and 11 000 t from China. Tin consumption is estimated at 165 700 t plus exports of 14 400 t to the U.S.S.R. and G.D.R. This leaves a deficit of 17 500 t. A similar calculation for 1986 showed a deficit of 22 000 t, suggesting that some 40 000 t of tin stocks were absorbed over the last two years. Comparatively, tin stocks on the LME at the end of 1987 were at 20 000 t, a fall of about 50 000 t from the peak of early 1986. Stocks elsewhere are unknown. Assuming that total tin stocks were around 100 000 t at the time of the tin crisis, they apparently had fallen to 50-60 000 t by the end of 1987, compared with a more realistic level of 25 000 t, or 8 weeks of consumption. Thus, an expected further reduction of 20 000 t in 1988 will lower stock levels close to the desirable level.

This should allow tin prices to strengthen somewhat toward the latter part of 1988. By then, tin prices could be at about US$3.50. If prices were to rise earlier or by a larger amount, tin production likely would increase and stock absorption could be substantially reduced.

USES

Tinplate traditionally has been the largest use of tin worldwide but falling tinplate demand in the developed world has more than offset gains in developing countries. Rising tinplate production in the developing countries is curtailing imports from developed countries. In the latter, competition from substitutes in the food and beverage market as well as thinner tin coatings have reduced consumption of tin for tinplate. In the United States, aluminum has taken over the large metal beverage container market. Similarly, the increasing popularity of the microwave oven has food producers looking at alternate packaging material like plastics and cellulose. Tinplate competition also comes from non-tin coated steels, tin-free steel (TFS) or electrolytic chromium coated steel (ECCS).

Solder is another traditional use of tin and in the United States and Japan it may now surpass tinplate as the largest tin user. Strong growth in the electronics industry has provided a new impetus for this tin use. Growth in tin solder is however limited by the trend towards the use of less solder per assembly. This trend is more evident in the increasing use of surface mounted components which permits greater solder savings. A growing regulatory trend in North America to replace the standard lead-tin solder for water pipes with silver-tin solder would increase tin consumption in solder, since the latter uses 95% tin vs 50% in the former.

Chemicals have been the fastest growing newer use for tin. Tin is used in an array of inorganic and organic chemicals, for application as P.V.C. stabilizers, agricultural pesticides, anti-fouling paints for ships and biocidal compounds for the protection of materials such as paints, textiles and building materials.

Tin is also used for tinning (which includes electronic uses, hot dipping and electroplating in the electronics industry), in the manufacture of pewterware, and in bronze, brass and other tin containing alloys. Tin containing alloys are used in construction, machinery and equipment and consumer durables.

Consumption of tin in tinplate is estimated at about 50 000 t in 1986. Tin in solder is estimated at 49 000 t. Given the uncertainty surrounding all such estimates, both uses are now more or less of equal importance for tin consumption. Solder is however expected to hold its own in the years to come while tinplate should continue its gradual fall as tinplate loses market share to other packaging materials. Demand for tin in chemicals reached about 21 000 t in 1986 and will keep increasing.

Most of the other traditional uses for tin, excluding tinning which is still growing, should either be stable or show a slight decline. Newer promising uses also include tin in cast iron and tin in powder metallurgy. Overall tin consumption in 1986 is estimated at 159 800 t and, in spite of lower tin prices, shows no sign of improvement. It appears that losses in traditional uses can at best be compensated by gains in new uses.

OUTLOOK

Short term

Tin prices should improve in the latter part of 1988 as total stock levels return closer to desirable levels. The price of tin is expected to reach US$3.50/lb. by the end of 1988. Tin markets should return to normal, i.e. equilibrium between production and consumption, by the end of 1989, when prices are expected to reach but not exceed US$4.00/lb. By 1990, Brazil, Indonesia and Malaysia will be vying for the position of largest producer, with Malaysia likely to be in third place.

Lower tin prices have not brought major changes in tin consumption, as tin consumption is rather price inelastic. Tin is not a major cost component of tinplate nor is solder a major cost component of electronic parts. Lower prices have however removed some of the pressure for substituting tin in some of its uses but price uncertainty will remain a factor in the short term.

Tin metal consumption is likely to remain more or less stable to the end of the decade. Losses in tin plate will be compensated by gains in other uses, especially chemicals.

Longer term

Dating as far back as 1921 with the Bandoeng Pool, the tin industry has been almost continously the subject of price controls in one form or another but free market pricing has now existed since 1986. The emergence of major new producers with differing interests outside of southeast Asia (Brazil and China) is lessening the industry's geographical concentration and cohesiveness. The continuation of free market pricing appears likely in the future. As a result and in view of the sufficient availability of resources, prices should remain fairly stable in real terms to the turn of the century, probably within the US$3.75 to $4.00/lb. range in real terms over this period.

Tin consumption should stabilize or marginally increase from present levels, even assuming that no major new use of tin is developed. Consumption of tin in tinplate will continue to fall but at a slower pace. Tin in chemicals should continue to grow and solder should hold its own. The tin industry needs new uses to improve its prospects for steady and substantial growth but most producers are from developing countries and R&D may not be their highest priority. However, the prospects for long term price stability and supply are a defininte plus in promoting tin use.

TARIFFS

Item No.		British Preferential	Most Favoured Nation (%)	General	General Preferential
CANADA					
	Metals, and manufactures:				
32900-1	Tin in ores and concentrates, n.o.p.	free	free	free	free
	Natural oxides, n.o.p., not including ores of metals:				
33507-1	Tin oxides	free	12.5	25.0	free
33910-1	Collapsible tubes of tin or lead coated with tin	10.0	10.2	30.0	free
34200-1	Phosphor tin in blocks, bars, plates, sheets, strips, rods and wire	5.0	5.5	10.0	3.5
34300-1	Tin, in blocks, pigs, bars or granular form	free	free	free	free
34400-1	Tin strip waste and tin foil:	free	free	free	free
	Sheet or strip of iron or steel, corrugated whether or not with a corrugated or other roll-formed profile, and whether or not with rolled surface pattern/cold-rolled or cold-drawn				
38203-1	Coated with tin or vitreous enamel	8.0	8.0	25.0	5.5
43220-1	Manufactures of tin plate, painted, japanned, decorated or not, and manufactures of tin, n.o.p.	11.1	10.2	30.0	6.5
UNITED STATES (MFN)					
	Metal bearing ores and the dross or residuum from burnt pyrites:				
601.48	Tin ore and black oxide of tin		free		
	Unwrought tin:				
622.02	Tin other than alloys of tin		free		
622.04	Alloys of tin		free		
622.06	Other		free		
622.10	Tin waste and scraps		free		
	Plates, sheets and strips, all the foregoing which are wrought, of tin, whether or not cut, pressed or stamped to nonrectangular shapes:				
622.15	Not clad		2.4		
622.17	Clad		4.8		
	Tin wire:				
622.20	Not coated or plated with metal		2.4		
622.22	Coated or plated with metal		4.2		
622.25	Bars, rods, angles, shapes and sections, all the foregoing which are wrought, of tin		4.2		
622.35	Tin powder and flakes		4.2		
622.40	Pipes, tubes and blanks therefor, pipe and tube fittings, all the foregoing of tin:		2.4		
	Base metal foil (whether or not embossed, cut to shape, perforated, etched, etc.) not backed and not cut to shape:				
644.15	Tin foil		7.0		

Sources: The Customs Tariff, 1987, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1987), USITC Publication 1910; U.S. Federal Register, Vol. 44, No. 241.

n.o.p. Not otherwise provided for.

TABLE 1. CANADA, TIN PRODUCTION, IMPORTS AND CONSUMPTION, 1985-87

	1985		1986		1987P	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Production						
Tin content of tin concentrates and lead-tin alloys	119	2 057	2 356	21 223	3 439	31 699
Imports					(Jan.-Sept.)	
Blocks, pigs, bars						
United States	1 074	17 273	1 495	14 862	1 383	12 451
Brazil	1 401	22 632	966	9 429	688	6 228
Bolivia	430	7 068	686	6 094	30	277
Indonesia	40	635	180	1 355	160	1 409
Singapore	460	7 556	59	450	180	1 568
Other countries	291	4 147	539	4 595	442	3 900
Total	3 696	59 311	3 925	36 785	2 883	25 833
Tinplate						
United States	480	579	4 402	4 898	512	555
Spain	-	-	89	59		
Greenland	-	-	17	17		
West Germany	54	34	-	-	1 324	1 060
United Kingdom	-	-	2	2	3	2
Total	534	613	4 510	4 976	1 839	1 618
Tin, fabricated materials, n.e.s.						
United States	304	1 363	397	1 746	285	1 248
West Germany	8	46	10	26	28	83
United Kingdom	14	107	10	38	23	107
Other countries	22	31	18	97	10	65
Total	330	1 547	435	1 907	346	1 503
Exports						
Tin in ores, concentrates and scrap[1]						
United Kingdom	100	292	1 763	7 928	1 870	19 666
Mexico	139	924	77	661	88	398
United States	102	619	1 887	416	32	156
Malaysia	0	0	0	0	90	95
Hong Kong	17	5	0	0	0	0
Total	358	1 841	3 727	14 857	2 080	20 315
Tinplate scrap						
United States	3 326	390	522	99	590	99
India	38	11	0	0	0	0
Hong Kong	0	0	102	28	0	0
France	15	1	0	0	0	0
Total	3 379	403	624	127	590	99
Consumption[2]						
Tinplate and tinning	2 492	..	2 300	..		
Solder	1 029	..	938	..		
Babbit	74[r]	..	179	..		
Bronze	285[r]	..	176	..		
Other uses (including collapsible containers, foil, etc.)	86	..	62	..		
Total	3 966[r]	..	3 655	..		

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Tin content of ores and concentrates plus gross weight of tin scrap. [2] Available data as reported by consumers.
P Preliminary; .. Not available; - Nil; n.e.s. Not elsewhere specified; [r] Revised.

TABLE 2. CANADA, TIN PRODUCTION, EXPORTS, IMPORTS AND CONSUMPTION, 1970, 1975 AND 1980-87

	Production[1]	Exports[2]	Imports[3]	Consumption[4]
		(tonnes)		
1970	120	268	5 111	4 565
1975	319	1 052	4 487	4 315
1980	243	883	4 527	4 517
1981	239	513	3 791	3 766
1982	135	601	3 235	3 528
1983	140	371	3 769	3 371
1984	209	315	4 105	4 076
1985	119	358	3 696	3 966
1986	2 356	3 727	3 925	3 655
1987P	3 439	2 080[5]	2 883[5]	

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Tin content of tin concentrates shipped plus tin content of lead-tin alloys produced. [2] Tin in ores and concentrates and tin scrap, and re-exported primary tin. [3] Tin metal. [4] Current coverage exceeds 90%, whereas until 1972, coverage was in the order of 80 to 85%; available data as reported by consumers. [5] Jan.-Sept. only.
P Preliminary.

TABLE 3. WORLD[1] TIN PRODUCTION, CONSUMPTION AND PRICES, 1970, 1975 and 1980-87

	Production			Prices	
	Tin in Conc.	Primary Metal	Consumption	Malaysia[2]	NY Dealer[3]
			(000 t)		
1970	185	185	185	10.99	1.74
1975	181	179	173	15.94	3.40
1980	201	198	174	35.72	7.73
1981	205	197	163	32.34	6.48
1982	190	180	157	30.09	5.86
1983	172	159	155	30.19	6.01
1984	167	161	165	29.16	5.67
1985	158	155	160	29.69	5.25
1986	139	148	165	15.49	2.94
1987e	136	148	166	16.83	3.15

Source: International Tin Council.
[1] Excludes countries with centrally planned economies, except Bulgaria, Czechoslovakia, Hungary, Poland, Romania and Yugoslavia. [2] Cash price ex-smelter for Grade A tin, shipment within 60 days, in Malaysian ringgits per kg, the ringgit being the unit used to define price levels under recent International Tin Agreements. [3] Metals Week, U.S. dollars per pound.
e Estimate.

TABLE 4. WORLD[1] CONSUMPTION OF PRIMARY[2] TIN, 1970 AND 1984-87

	1970	1984	1985	1986	1987[e]
			(tonnes)		
EEC, total[3]	58 246	40 710	38 285	41 799	42 004
West Germany	14 062	15 591	15 668	16 884	16 978
France	10 500	7 799	6 900	7 461	7 359
United Kingdom	16 951	5 838	6 000	6 000	6 200
Netherlands	5 467	4 842	4 253	4 009	4 246
Italy	7 200	4 500	5 000	4 560	4 800
Belgium/Luxembourg	3 000	1 697	920	1 141	1 220
United States	53 807	37 819	37 136	32 548	34 000
Japan	24 710	33 275	31 594	31 521	32 425
Spain	3 040	3 900	3 100	2 600	2 600
Poland	..	3 634	3 029	3 624	2 824
Brazil	2 139	4 271	4 644	5 875	7 367
Canada	4 640	4 106	3 781	3 600	3 600
Czechoslovakia	3 420	3 000	2 800	3 200	3 200
Republic of Korea	394	3 632	2 600	4 335	4 000
Australia	3 837	2 600	2 600	2 460	2 400
Total, incl. Others	184 800	164 800	159 600	165 100	165 700

Source: International Tin Council.

[1] Excludes countries with centrally planned economies, except Bulgaria, Czechoslovakia, Hungary, Poland, Romania and Yugoslavia. [2] May include secondary tin in some countries.

[3] Includes all 1982 members in all years except Greece in 1970.

.. Not available; [e] Estimate.

TABLE 5. WORLD[1] PRODUCTION OF TIN-IN-CONCENTRATES, 1970 AND 1984-87

	1970	1984	1985	1986	1987[e]
			(tonnes)		
Malaysia	73 794	41 307	36 884	29 134	30 845
Indonesia	19 092	23 223	21 758	24 634	26 321
Bolivia	30 100	19 911	16 136	10 479	8 000
Thailand	21 779	21 607	16 593	16 792	15 305
Brazil	3 610	19 957	26 514	25 449	26 800
Australia	8 828	7 922	6 934	8 470	8 038
United Kingdom	1 722	5 047	5 200	4 345	3 200
South Africa	1 986	2 301	2 193	2 055	1 673
Peru	20	2 991	3 807	4 817	5 202
Zaire	6 458	2 410	2 177	1 889	1 900
Total, incl. Others	184 900	167 400	158 200	139 200	135 600

Source: International Tin Council.

[1] Excludes countries with centrally planned economies, except Czechoslovakia, Poland and Hungary.

[e] Estimate.

TABLE 6. WORLD[1] PRODUCTION OF PRIMARY TIN METAL, 1970 AND 1984-87

	1970	1984	1985	1986	1987^{e}
			(tonnes)		
Malaysia	91 945	46 911	45 500	43 788	44 776
Indonesia	5 190	22 467	20 418	22 080	23 820
Thailand	22 040	19 729	17 996	19 672	16 407
Bolivia	300	15 842	11 400	7 673	6 000
Brazil	3 100	18 877	24 703	25 104	26 411
United Kingdom	22 035	7 105	7 548	9 227	11 939
Netherlands	5 937	6 188	5 308	5 114	4 004
Australia	5 211	2 687	1 421	1 399	669
Spain	3 908	3 426	3 291	1 725	1 961
United States	4 540	4 000	3 000	3 213	2 000
South Africa	1 491	2 200	2 056	1 816	1 608
Singapore	..	3 500	5 308	500	1 000
Nigeria	8 069	1 253	1 027	91	644
Total, incl. Others	184 900	161 200	155 400	148 000	147 600

Sources: International Tin Council.

[1] Excludes countries with centrally planned economies, except Czechoslovakia, Poland and Hungary.

.. Not available; ^{e} Estimate.

TABLE 7. MONTHLY AVERAGE TIN PRICES[1], 1986 AND 1987

	NY Dealer US¢/lb.		Malaysia Ringgit/kg	
	1986	1987	1986	1987
January	369.29	316.10	..	17.28
February	433.68	316.00	19.56	17.00
March	318.57	314.61	18.40	16.72
April	270.05	317.09	14.69	16.64
May	256.62	319.43	14.22	16.69
June	256.48	313.57	14.09	16.57
July	255.41	302.63	14.23	16.27
August	255.60	311.71	14.09	16.62
September	258.31	316.48	14.11	16.88
October	267.80	318.17	14.53	17.11
November	287.61	323.84	15.90	17.29
December	300.00	317.72	16.68	17.02
Yearly average	294.12	315.61	15.49	16.83

Sources: Metals Week; International Tin Council.

[1] Prices are for Grade A (in the United States) or High Grade (99.85% tin or more).

.. Trading suspended.

Titanium and Titanium Dioxide

D.E.C. KING

SUMMARY

The strong worldwide demand for titanium raw materials, led by titanium dioxide pigments, has continued from 1984 through 1987. Producers everywhere operated at or near full capacity in attempting to satisfy the demand.

QIT-Fer et Titane Inc. (QIT), which increased the production capacity of its mine and smelter to over 900 000 t/y of 80% TiO_2 slag in 1986, was slated to reach just over a million t/y of slag by mid-1988 and may further increase production capacity to 1.2 Mt/y after that. In 1987, both Canadian pigment producers were operating at their full capacity of about 36 000 t/y of TiO_2 pigment each. NL Chem Canada, Inc. began commissioning its new chloride process pigment plant in November.

CANADA

Canadian titanium-based industries include ilmenite mining and smelting, titanium oxide and pigment production, titanium metal fabrication to finished parts, coating of welding rods, and the manufacture of titanium carbide and nitride coated parts. Also, titanium-bearing master alloys are incorporated into special steel and aluminum alloys. The mining, smelting and pigment operations are carried out exclusively in Quebec, whereas the downstream activities are located in several provinces. Canada does not have any capacity for producing primary titanium (in the form of sponge or granules) or ferrotitanium. Capacity for vacuum melting of primary titanium to produce billets exists at Eldorado Nuclear Limited, Port Hope, Ontario. Facilities to vacuum melt, custom forge and roll billets existed at the Atlas Titanium division of Atlas Steels division of Rio Algom Limited at Welland, Ontario, but these operations were discontinued in the 1970s.

QIT-Fer et Titane Inc. (QIT) is the only company that mines titanium ore in Canada. Ilmenite, a mineral containing somewhat more iron than titanium, is mined at Lac Allard, Quebec. The raw ore is shipped to Tracy, Quebec where it is beneficiated, and the concentrate is smelted to produce high quality pig iron and titania (TiO_2) slag (Sorelslag), which is used as feedstocks by titanium dioxide pigment producers. Just before mid-1987, The British Petroleum Company p.l.c. acquired control of The Standard Oil Company (Sohio), which owns Kennecott Corporation and QIT.

The slag produced from ilmenite mined by QIT is suitable as feedstock for titanium dioxide pigment produced by the sulphate process. Plants based on this process are gradually being phased out and replaced by chloride process plants requiring higher quality slag. Because of its major shareholding in Richards Bay Minerals (RBM) of South Africa, QIT is able to supply 85% TiO_2 slag from RBM to the chloride process market.

QIT was proceeding with a $130 million expansion of its Lac Allard ilmenite mining and Tracy smelting operations in Quebec. This project will increase its capacity by 175 000 t/y of 80% TiO_2 slag and 150 000 t/y of high purity pig iron. The project is due for completion in the third quarter of 1988 and includes the refurbishment of two electric furnaces to bring them up to the capacity of the other seven furnaces, and the upgrading of plant water, gas and electrical systems. The expansion will raise total production capacity to over 1 Mt/y of 80% slag.

In April 1986, QIT entered into a joint venture partnership with the Madagascar government to develop beach sand deposits containing high grade ilmenite. If the results of on-going exploration and feasibility studies warrant it, plans call for QIT to develop and begin mining the deposits by the second half of 1990. The proposed mining rate was raised from 300 000 to 600 000 t/y of ilmenite, some of which would be smelted at Tracy, Quebec to produce 90% TiO_2 slag and the balance marketed to sulphate plants without further processing. The slag would be suitable for both types of pigment plants.

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Most of QIT's output of Sorelslag is exported to the United States and Europe, and approximately 10 to 15% is sold in Canada to two pigment producers, NL Chem Canada, Inc. at Varennes, and Tioxide Canada Inc. at Tracy, Quebec. Both pigment producers employ the sulphate process.

The total Canadian consumption of titania pigment, about 80 000 t/y, approximately matches the present total Canadian production capacity. However, some grades of pigment are imported, the total amounting to about 27 700 t in 1986. A corresponding amount of Canadian production is exported, mainly to the United States.

The new chloride process pigment plant announced by NL Chem Canada, Inc. in 1985 began to be commissioned in November 1987. It was expected to reach its full production capacity of 38 000 t/y in late 1988 or early 1989. The principal feedstock for the plant may be RBM 85% TiO_2 slag supplied by QIT, supplemented by natural or synthetic rutile. Feedstock supplies at some future date could include 90% TiO_2 slag smelted from Madagascar ilmenite.

Chloride processes for producing pigment have been gradually replacing sulphate plants, mainly for environmental reasons. They produce less waste products because they recycle the chlorine reagent and generally use higher grade feedstocks such as rutile, synthetic rutile and high quality slag. On a cost per unit of TiO_2 basis, titaniferous slag is said to be cheaper than natural and synthetic rutile.

Notwithstanding the general trend away from the sulphate process, there were further announcements of sulphate plant expansions in 1987.

A pilot plant was being financed jointly by QIT, NL Chem, and Tioxide. The other joint venture participant, Chemetics Ltd., is contributing engineering design to the project, which will treat dilute sulphate effluent from Tioxide's plant to produce strong acid by evaporation. Commissioning was begun and test data should become available by mid-1988. Successful results would be encouraging to the future of the sulphate process and might prevent future closures.

Both Canadian pigment companies have been able to increase production to a marginal extent with their existing sulphate process plants. However, neither company has plans for the construction of new plant capacity in Canada beyond NL Chem's current chloride plant project.

A small number of Canadian companies make finished products from titanium forgings, castings, bar, pipe, tube, plate and sheet. Walbar of Canada Inc. of Toronto, Ontario and Pratt & Whitney Aircraft Services of Canada Limited of Longueuil, Quebec, carry out machining operations on forgings, investment castings, and bar stock to produce parts for turbine engines. The shop scrap is sold to U.S. producers of ferrotitanium and briquettes, which are made from titanium scrap and off-grade sponge. The total amount of titanium forgings, castings and bar stock consumed by such companies is in the order of 300 t/y.

Titanium Ltd. of St. Laurent, Quebec and Ellett Copper & Brass Co. Limited of Port Coquitlam, British Columbia, custom produce titanium tanks, pressure vessels, heat exchangers, fans, and other equipment for pulp, chemical, petrochemical and metallurgical industries.

The aircraft companies, The de Havilland Aircraft of Canada, Limited, Downsview, Ontario, Canadair Limited, Montreal, Quebec, and McDonnell Douglas Canada Ltd., Malton, Ontario, produce aircraft parts such as firewalls, motor mounts, nacelles and wings. The quantities of titanium used in making chemical equipment and airframes in Canada vary widely, but appear to be in the order of 50 to 150 t/y for chemical equipment and 10 to 50 t/y for aircraft parts.

The quantities of titanium added as ferrotitanium and composite master alloys to specific grades of steels are small compared with some alloying elements. Canada nevertheless imported approximately 460 t of contained titanium in 1986 and about 400 t in the first nine months of 1987. Used as an alloying agent, titanium is beneficial in controlling nitrogen and acts as a grain refiner in high-strength-low-alloy (HSLA) steel plate; it is also used as a carbide stabilizer in type 409 stainless steel. By comparison, the quantities of titanium added to aluminum alloys are of a much smaller order, possibly about 10 t/y of titanium in 5 to 10% titanium-aluminum master alloys.

Canadian companies that produce wear resistant parts for the mining and other industries use very small amounts of titanium, which are not separately reported in statistics. Titanium is used in mixed carbides with tungsten, and in titanium nitride coatings. Canadian companies producing carbides and nitrides include Kennametal Ltd., General Electric Canada Inc. and Valenite-Modco Limited. Fluxes for welding rods are produced from imported rutile.

WORLD DEVELOPMENTS

Titanium Minerals

Ilmenite, an iron titanate, is the source for 90% of the world supply of titanium dioxide pigment production. The more expensive rutile, a titanium dioxide mineral, is sometimes used by the chloride segment of the pigment industry and is generally favoured by producers of primary titanium metal. Anatase, another titanium dioxide mineral, exists in large quantities in Brazil and is likely to become another important feedstock.

Titaniferous slag and synthetic rutile, which are produced by different processes from ilmenite, are high-grade feedstocks which are growing in prominence as world reserves of natural rutile are depleting. The availability of these alternative materials should tend to reduce the upward pressure on natural rutile prices.

Titanium Dioxide Pigment

The current annual growth of TiO_2 pigment demand of about 2.3% is expected to continue over the next 5 years. The approximate consumption by use is 60% in paint, 13% in paper, 15% in plastics, and the remainder divided between, rubber, ink, textiles and ceramics. North America's usage in paper (20%) exceeds the average for the rest of the world by a substantial margin.

As a result of mergers and acquisitions over recent years, there are now four major world pigment producers: E.I. du Pont de Nemours and Company (Dupont), Tioxide International Ltd. (Tioxide), NL Chemicals, Inc. (NLC), and SCM Corporation (SCM). Concern over the large amounts of dilute sulphuric acid and ferrous sulphate waste generated by the sulphate process plants has prompted companies either to install expensive waste treatment facilities or, because of the consequent increase in operating costs, to terminate operations as has happened in the United States in particular. Part of the lost capacity has been replaced by chloride process plants, built mainly outside of North America.

The sulphate plant closures occurred largely during the last period of weak demand for pigment. Since that period, plans for replacement capacity have lagged behind the strong resurgence of demand that has occurred since 1984. Replacement plans have been further retarded because profit margins in the industry have been relatively low.

Operating costs of the chloride process are approximately in the proportions 40% fixed costs, 40% variable costs, 10% laboratory and 10% plant materials. The largest variable cost is in raw materials, but the biggest unit operating cost is in "finishing", which involves re-slurrying and re-drying in order to coat the pigment particles with compounds which reduce the absorption of ultraviolet light. The latter causes the deterioration of organic paint bases.

Apart from raw materials, a large component of sulphate process operating cost is sulphuric acid. Fossil fuel energy is the next largest cost component. Fuel and acid costs were fairly stable in 1987.

Titanium Metal

Titanium metal comprises less than 6% of total titanium ore demand. World consumption of titanium sponge increased in the late 1970s and reached an all-time peak of 51 412 t/y in 1981. This rapid growth stimulated increases in production capacity, which in 1983 totalled about 68 000 t/y of primary titanium in the market economies. Present global capacity includes about 33 400 t/y in the United States, 38 900 t/y in Japan where the greatest expansion took place, and 5 000 t/y in the United Kingdom. However, the U.S.S.R. had the world's largest production capacity, reported to be approximately 50 000 t/y. China's capacity has been estimated at about 2 500 t/y.

The western world capacity for ingot melting amounted to a total of about 80 000 t/y in 1984, including 59 000 t/y in the United States, 13 000 t/y in Japan, 5 000 t/y in the United Kingdom, 2 000 t/y in West Germany and 1 000 t/y in France.

U.S. consumption of titanium sponge declined from 22 400 t in 1984 to 19 600 t in 1985, 17 700 t in 1986 and 13 500 t in the first three quarters of 1987. The declining demand for sponge has been somewhat offset by higher scrap consumption; 15 000 t in 1986 and 12 600 t in the first three quarters of 1987. U.S. production of titanium sponge has been 15 800 t in 1986 and 12 800 t in the first three quarters of 1987, the latter being 20% higher than the comparable period in 1986. Japanese production of titanium sponge was expected to be 12 000 t in 1987, about 25% lower than in 1986. Japanese exports to the United States have suffered from the rising exchange rate of the yen against the dollar and slowed virtually to a stop by mid-1987. The total book capacity of 27 000 t of sponge production in Japan may be reduced to an effective 19 000 t if Japanese sponge producers scrap a portion of their idled capacity. Because of firming demand, Japanese production might increase to 15 000 t in 1988.

Titanium ingot consumption in the United States declined from 35 700 t in 1985 to 30 700 t in 1986 and 24 600 t for the period January through September 1987. Probable overall U.S. ingot consumption in 1987 was 32 000 to 33 000 t. U.S. ingot production during 1986 was 31 800 t and the total in 1987 was probably close to 33 000 t.

The consumption of mill products in the United States, which amounted to 21 000 t in 1985, dropped to 18 900 t in 1986. Consumption in 1987 will probably be about 20 000 t.

A flat market for titanium metal products existed throughout 1986 and the first half of 1987, despite large orders for commercial aircraft and low metal prices. Various explanations have been suggested by industry experts; for example, the newer aircraft use less titanium and the quantity of titanium processed to produce a final finished part is gradually being lowered by technology improvements and by the increasing utilization of scrap.

The distribution of U.S. usage for mill products in 1984 was estimated by the U.S. Bureau of Mines to be 75% for aerospace and 25% for industrial applications. Japan's consumption depends far less on the volatile military market; less than 10% is used in aerospace applications and more than 90% in industrial applications. In western Europe, industrial applications account for 40 to 50% of consumption and aerospace applications account for the remainder.

Developments by Country

Australia: The new synthetic rutile plant of Associated Minerals Consolidated Ltd. (AMC), a wholly owned subsidiary of Renison Goldfields Consolidated Ltd. (RGC), was reported to be experiencing commissioning problems following its opening in April 1987. The new 112 500 t/y plant is located at Narngulu near Geraldton and would add to AMC's existing 60 000 t/y operation at Capel. The mineral sands operations of RGC, including the former Allied Eneabba Ltd. operations, account for approximately 30% of the world's rutile capacity, 40% of synthetic rutile, 45% of zircon and 40% of monazite.

Westralian Sands Ltd. (WSL) closed its Capel mine and opened a new mine at Boyanup. A third mine is due to open at Capel in the third quarter of 1988. WSL's new 100 000 t/y synthetic rutile plant, designed and built by Lurgi, came on-stream in December 1987. The new plant will enable WSL to supply chloride process plants for the first time.

TiO_2 Corporation NL, which was established in 1985 to develop new mineral sand deposits at Cooljarloo and Jurien, was acquired in mid-1987 by Minproc Holdings Ltd. (Minproc). The Cooljarloo deposit north of Perth was declared viable in early 1987 but the Jurien deposit had lower potential. Minproc has targeted Cooljarloo production for mid-1990 at a cost of A$65 M. This will be a joint venture between TiO_2 Corp., Minproc and Kerr-McGee Chemical Corporation. The project is to include a mine, concentrator, synthetic rutile plant and a TiO_2 pigment plant, and will use Kerr McGee technology in the latter two facilities.

CRA Limited reported that its heavy mineral deposit near Horsham, Victoria, probably contains 4.9 billion t of ore averaging more than 2% heavy minerals, with 1 billion t averaging 3% in the core. The core contains probable reserves of 3.4 Mt of rutile and anatase, 12.5 Mt of ilmenite, 4.6 Mt of leucoxene, 5.1 Mt of zircon, 580 000 t of monazite and 170 000 t of xenotime. Despite fine-grained mineralization, high recoveries were reported in initial pilot plant tests. In 1987, CRA Limited established a subsidiary company, Wimmera Industrial Minerals Pty Limited, to develop the deposit.

SCM Chemicals Inc. was reported to be planning to increase the capacity of its TiO_2 pigment plant at Bunbury, Western Australia from 40 000 t/y to 77 000 t/y at a cost of A$107 M. Plant completion is due in late 1988. The increased capacity is to be achieved by replacing the existing sulphate process by a new chloride plant on a nearby site.

Sierra Leone: The Sierra Rutile Ltd. mine expansion of Nord Resources Corp. was expected to be completed in the last quarter of 1987. The $18 M upgrading of its dredging operations will increase rutile production capacity nearly 30% to 128 000 t/y from 100 000 t.

Brazil: Dupont's Brazilian subsidiary and Constructora Andrade Gutierrez SA, a large construction firm, proposed to form a joint venture to construct a 60 000 t/y TiO_2 pigment plant by 1991. The $180 M plant would be located near the proposed 88 000 t/y anatase concentrator.

South Africa: Richards Bay Minerals (RBM) was reported to have completed its expansion to 650 000 t/y of 85% TiO_2 slag.

Mozambique: Extensive beach sands, initially explored by the Geological Survey of Yugoslavia (GEO), are to be developed in a 50/50 joint venture between GEO and Kenmare Resources PLC of Dublin, Eire. The deposit lies on the northeast coast between Angoche and Sangagi. It contains 28 Mt of 8% heavy minerals with the distribution 83.6% ilmenite, 2.6% rutile, 8.1% titanomagnetite, 4.4% zircon and 1.3% monazite. Mineral dressing tests indicated possible recoveries of 85-90%. Prefeasibility studies are due to be completed by February 1988, and tentative plans are for a mining and milling capacity of 1.2 Mt/y of ore. Production could start in 1989.

It was also reported in 1986 that Edlow Resources, a U.S. firm had been awarded the right to explore and develop titanium bearing beach sands on a 200 km stretch of coastline near Pebane.

Norway: The new plant of K/S Illmenittsmelteverket A/S at Tyssedal designed to produce 200 000 t/y of 75% TiO_2 slag, was reported to be experiencing difficulties in commissioning during 1987. The technological problems are serious and may require a large financial assistance from the Norwegian government.

Saudi Arabia: No engineering company has yet been selected for the previously announced project to build a 45 000 t/y pigment plant by mid-1989. It is therefore unlikely that the target date will be achieved.

Singapore: ISK Singapore Pte Ltd. (ISK), a subsidiary of Ishihara Sangyo Kaisha Ltd., began construction of the first of two phases of a 72 000 t/y chloride process TiO_2 pigment plant in mid-1987. The reported cost of each phase was about US$100 M. The plant will consume synthetic rutile from Westralian Sands Ltd., which is associated with ISK. The first phase is due for completion in the second quarter of 1989.

United States: Rutile and titanium bearing slag were certified by Congress as strategic materials and exempted from the import restrictions of the Anti Apartheid Act of 1986.

A demonstration plant is to be built to test a U.S. Bureau of Mines process to recover TiO_2 from wastes generated during the chlorination of concentrates. The plant will be operated by the Ashtabula Trading Company of Ohio.

Kerr-McGee Chemical Corporation will expand its chloride TiO_2 pigment plant at Hamilton, Mississippi from 85 000 t to 106 000 t/y by the middle of 1989.

SCM Chemicals announced plans to spend $18 M to expand the capacity of its Ashtabula, Ohio pigment plant from 52 000 to 70 000 t/y.

Wyman-Gordon Co. of Worchester, Mass. indicated its intention to close down its sponge operations and one of its forging plants by the end of 1987. Only three integrated titanium mill producers will remain in the United States, namely RMI Company, Niles, Ohio, the Timet division of Titanium Metals Corp. of America, Pittsburgh, Pennsylvania, and Oregon Metallurgical Corporation (OREMET), Albany, Oregon.

Albany, Titanium, Inc. was scheduled to start producing titanium powders for specialty alloys in mid-1987. Its output is expected initially to be 75 000 lb./y and sponge would also be produced at a later date.

Timet announced that it would begin production of titanium aluminide in production size heats of 7 000 lbs. in the third quarter of 1987. Companies that have wanted to use titanium aluminide have had difficulty in obtaining supplies. Rohr Industries, Inc., which has been developing honeycomb structures of the material, is one firm which has experienced this supply problem.

Holland: NL Chemicals SA, a subsidiary of NL Industries, Inc., planned to construct a chloride process pigment plant at Langerbrugge, near Ghent, by the end of 1989. The plant would replace an existing sulphate plant of 40 000 t/y capacity that has operated since 1957.

China: Among plans for expansion in several industries, China intended to expand the Baoji nonferrous metal works for titanium fabrication, with the objective of increasing production of fabricated titanium parts from 500 t to 2 000 t/y. No schedule was announced.

PRICES

The depressed prices of titanium metal, which have prevailed for the past several years due to over capacity and flat demand, began to firm in 1987. U.S. sponge producers, which have experienced rising energy and material costs, have been losing money.

Japanese producers were unable by mid-year to export to the United States because of the high value of the yen. Thus, when Timet increased its price for commercially pure titanium plate by 4 to 6% and RMI Company raised its prices for aircraft quality titanium billet and sheet by 4 to 8%, and for commercially pure titanium plate by 3%, the prices held at the higher levels in the market place.

Published prices for titanium dioxide pigment increased by 3 to 4.5% in 1987. However, many consumers found themselves unable to obtain supplies and have been obliged to pay spot prices greatly in excess of published prices.

Ilmenite quotations in the Metal Bulletin showed no increase during 1987. The price for bulk ilmenite, f.o.b. Australia, remained at A$70-80/t throughout the year.

Upward pressure on natural rutile prices may be somewhat relieved by the increasing availability of synthetic rutile.

USES

Titanium metal usage is based on its relative abundance, unique physical properties and corrosion resistance. Initially, uses were found in military aircraft where cost was not the main factor, and its high strength, lightness and high melting point could be utilized for engine and airframe applications. Greater availability and lower prices have led to expanding usage in commercial and private aircraft. Specifications for aircraft quality are high, and since titanium has a strong tendency to combine with oxygen and nitrogen, melting has to be carried out in vacuum, sometimes twice or three times before an ingot is produced for fabrication.

Commercial titanium that is unalloyed or produced to less demanding specifications is used in industrial applications. Titanium's high corrosion resistance lends itself to a wide range of uses in the chemical, metallurgical and paper industries, and in power and desalination plants. In these applications, about 50% of the total quantity of titanium consumed is used in heat transfer and seawater cooling applications, about 25% in chemical process equipment, and about 20% as electrodes in electrolytic plants. However, a vast number of minor applications are developing, such as spectacle frames, camera parts, yacht rigging, and prosthetic uses such as hip joints and dental implants. Titanium-nickel shape memory alloys, which spring back to their original shape when heated, are gaining a wide range of uses in high pressure pipe couplings, electronic connectors, robotics and eyeglass frames.

TECHNOLOGICAL DEVELOPMENTS

Mill producers have been caught in a squeeze between low prices and high operating costs, which could result in the closure of some operations. This situation particularly affects non-integrated producers whenever sponge and scrap prices are firmer than those of mill products. Although lower prices would be necessary for titanium to penetrate markets now served by aluminum and stainless steel, further production cost reductions would be necessary to enable this to happen to any substantial extent. A fundamental improvement would result from lower production costs for titanium sponge. Towards this end, Albany, Titanium, Inc. of the United States and Elettrochimica Marco Ginatta of Italy have carried out pilot studies on a fluosilicate leach and a fused salt electrolysis approach, respectively, for primary titanium. Both companies have also announced plans for commercial development, which so far have not reached the construction stage.

While no commercial breakthrough has yet occurred in primary titanium production, progress continues to be made on post-primary metal treatments including melting, forming, casting, recycling and powder metallurgical technologies, which have had the overall effect of reducing the cost of the finished parts, and improvements in quality. Much of the development work has been aimed at reducing excessive machining operations between the ingot and fabricated part stages. The cost and material savings obtained from the development of net-shape and near-net-shape techniques have enabled designers to specify titanium alloys in an expanded range of applications. The greatest commercial success in this regard has so far occurred through developments in precision casting techniques, which have enabled parts to be made in one piece instead of an assembly of many. Although not as successful so far, powder metallurgy techniques enable a very high utilization of material, albeit with unit size limitations. Also, super plastic forming and diffusion bonding are gaining use because this technology enables the design of large complex structural shapes with fewer component parts. Electron beam and plasma melting in inert atmospheres are being developed to larger scale and are replacing vacuum arc melting to some extent.

In the field of alloy development, the workhorse 6/4 alloy is being replaced for some applications by other alloys. For example, where better cold formability is required the alloy Ti3A12.5V is being used. Although not as strong as 6/4, the 3/2.5 has excellent ductility, which enables its use in complex and severely bent tubing shapes. For industrial uses requiring corrosion and abrasion resistance, unalloyed titanium is normally used, either in solid form or as cladding on a steel base. Explosion cladding has been the state-of-the-art technology but Nippon Kokan KK has developed technology for cladding by hot rolling, which has hitherto been impossible because of the formation of brittle intermetallic compounds at elevated temperatures. Surface modification based on electron beam or plasma techniques is also being carried out by various firms to provide corrosion and abrasion resistance. New titanium matrix composites and titanium aluminides are foreseen as having the potential to push titanium into higher strength-to-density ratios and higher temperature usage. Titanium aluminide is competing with aluminium lithium developments in some aircraft applications. Alloying progress is also being made in the areas of superconductive TiCb alloys and shape-memory TiNi alloys. However the future of metallic superconductors is questionable in light of the dramatic development of ceramic oxide superconductors in 1987, with potential for operating at higher cold temperatures. Indirectly, some savings in sponge production costs have been achieved through more successful upgrading of titanium scrap for recycling to sponge production.

The trend towards higher performance in aerospace is resulting in higher service requirements, particularly in parts exposed to high temperatures. Superalloys and titanium have hitherto been used in turbine engines below 800-1000°F. Researchers at National Aeronautics and Space Administration (NASA) have developed an aluminide-silicide coating which increases the heat resistance of titanium and would enable its use at temperatures of 1050-1200°F. The coating is applied by vapour deposition, followed by "sputtering", and acts as an oxygen barrier to prevent embrittlement of the titanium. This may be suitable for the next generation of engines. However, designers are considering future engines that would require service temperatures over 2500-3000°F. Ceramics, while able to satisfy such temperature requirements, have not yet been developed to withstand the mechanical stresses. Composites of ceramics and metals may fulfill some interim roles.

McDonnell Douglas is fabricating parts for mechanical strength, using metal matrix composite (MMC) components and super plastic forming (SPF), in an Air Force program to develop advanced manufacturing techniques that incorporate boron fibre-reinforced titanium.

OUTLOOK

The depletion of natural rutile supply will continue to encourage the conversion of ilmenite to titaniferous slag and synthetic rutile to meet the rising demand. Anatase could partially substitute for declining supplies of natural rutile but its eventual impact on this market will depend on supplies, prices and the relative suitability of all the alternative feedstocks to the two basic pigment processes. Production plans for feedstocks of all kinds appear to be adequately in balance with the anticipated growth in demand into the early-1990s, and any future price increases are likely to be moderate or approximately in proportion to pigment prices.

As has been the case for titanium raw materials since 1984, the demand for titanium dioxide pigment was strong throughout 1987, with plants operating near full production capacity. This market strength is expected to continue throughout 1988. Increases in prices resulting from the strong demand and tight supply have encouraged plans for capital investment in various countries, as outlined in the foregoing sections.

Pigment production plans have tended to lag behind demand in past years because prices have hitherto not been high enough to encourage new capital intensive greenfield plants. Stricter environmental regulations have also been a constraint. Pigment plants have been working at capacity for nearly four years in an attempt to keep customers supplied. Recent construction decisions have undoubtedly been made easier by increases in pigment prices, which occurred over the past year. The plans announced by pigment producers over the last two years began to result in additional capacity by the end of 1987 and should increase through 1989. Nevertheless, supplies are expected to remain tight into the early-1990s. On the other hand, the higher prices may reduce demand through substitution or give rise to other economies by pigment consumers.

Officials in the titanium industry continue to foresee slow growth in demand for metal products over the next five years. In 1986, a United States interdepartmental study forecasted an overall 4.9% consumption growth rate in the United States for aerospace and 6.1% for other applications from a 1982 base, leading to a total fabricated titanium metal consumption of 28 000 t in 1993.

TARIFFS

Item No.		British Preferential	Most Favoured Nation (%)	General	General Preferential
CANADA					
32900-1	Titanium ore	free	free	free	free
34715-1	Sponge and sponge briquettes, ingots, blooms, slabs, billets, and castings in the rough, of titanium or titanium alloys for use in Canadian manufactures (expires June 30, 1987)	free	free	25	free
34735-1	Tubing of titanium or titanium alloys having an outer diameter of less than 12.7 mm or more than 63.5 mm and having a wall thickness of less than 0.457 mm or more than 1.166 mm, for use in Canadian manufactures (expires June 30, 1987)	free	free	25	free
34736-1	Sheet or strip of titanium or titanium alloys, cold-rolled, not more than 4.75.mm in thickness, for use in the manufacture of tubes (expires June 30, 1987)	free	free	25	free
34745-1	Bars, rods, plate, sheet, strip, foil, wire, coated or not; forgings and mesh of titanium or titanium alloys, for use in Canadian manufactures (expires June 30, 1987)	free	free	25	free
37506-1	Ferrotitanium	free	4.0	5	free
92825-1	Titanium oxides	free	10.0	25	free
93207-6	Titanium whites, not including pure titanium dioxide	free	10.0	25	free
UNITED STATES (MFN)					
422.30	Titanium compounds		4.9		
473.70	Titanium dioxide		6.0		
601.51	Titanium ore (including ilmenite, ilmenite sand, rutile, and rutile sand)		free		
606.46	Ferrotitanium and ferrosilicon titanium		3.7		
629.12	Titanium metal, waste and scrap		7.2		
629.14	Titanium metal, unwrought		15.0		
629.20	Titanium metal, wrought		15.0		

Sources: The Customs Tariff, 1987, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1987), USITC Publication 1910; U.S. Federal Register Vol. 44, No. 241.

TABLE 1. CANADA, TITANIUM PRODUCTION AND TRADE, 1985-87

	1985		1986		1987P	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Production (shipments)						
Titanium dioxide, slag	x	x	x	x	x	x
Imports					(Jan.-Oct.)	
Titanium in ores and concentrates						
United States	1 619	1 147	2 775	1 065	1 536	1 044
Australia	340	150	119	59	6 780	3 222
Norway	-	-	-	-	889	119
Total	1 959	1 297	2 894	1 124	9 206	4 385
					(Jan.-Sept.)	
Titanium dioxide, anatase						
United States	2 657	4 705	1 581	3 352	3 698	7 662
West Germany	5 502	7 229	5 328	8 531	7 341	6 032
Australia	800	1 458	-	-		
France	903	1 389	263	475	304	615
Belgium-Luxembourg	324	471	508	846	213	401
United Kingdom	208	325	59	109	148	158
Spain	464	657	0	0	0	0
Other countries	2 211	2 961	198	350	330	683
Total	13 069	19 195	7 937	13 663	12 034	15 551
Titanium dioxide, rutile						
West Germany	2 224	3 020	5 250	9 864	3 041	5 957
United States	6 862	11 622	10 406	19 164	9 437	17 944
Belgium-Luxembourg	350	506	54	112	38	100
Spain	429	675	327	519	253	411
Other countries	3 652	5 883	3 720	5 705	2 866	5 622
Total	13 557	21 706	19 757	36 728	15 635	30 034
Titanium metal						
United States	479	15 110	389	15 588	133	8 387
Belgium-Luxembourg	8	831	8	865	1	71
United Kingdom	25	573	40	808	5	494
Japan	72	734	54	633	37	486
Other countries	3	206	2	60	1	28
Total	589	17 511	492	17 924	277	9 461
Ferrotitanium[1]						
United Kingdom	100	373	213	859	298	825
Italy	-	-	18	84	-	-
United States	288	1 153	230	915	103	379
Total	388	1 527	461	1 859	401	1 204
Exports[2] to the United States						
Titanium metal, unwrought, including waste and scrap	146	350^{e}	260	620	80	..
Titanium metal, wrought	390	7 000^{e}	399	7 088	210	..
Titanium dioxide	24 184	30 000^{e}	22 234	28 562	11 806	..
Titanium slag	177 100	..	176 048	..	136 000	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Total alloy weight. [2] U.S. Department of Commerce, U.S. General Imports, Report F.T. 135. Canadian export statistics do not provide separate categories.
P Preliminary; ^{e} Estimate; - Nil; x Confidential; .. Not available.

TABLE 2. CANADIAN TITANIUM PRODUCTION AND IMPORTS 1970, 1975 AND 1979-87

	Production		Imports		
	Ilmenite[1]	Titanium Dioxide Slag[2]	Titanium Dioxide Anatase	Titanium Dioxide Rutile	Total Titanium Dioxide Pigments
			(tonnes)		
1970	1 892 290	766 300	2 523	7 415	9 938
1975	1 543 480	749 840	2 467	241	2 708
1979	1 004 260	477 030	9 815	1 515	11 330
1980	1 853 270	874 710	6 135	148	6 283
1981	2 008 117	759 191	6 986	314	7 300
1982	1 735 000	669 000	5 737	369	6 106
1983	W	W	12 968	5 555	18 523
1984	W	W	16 188	9 369	25 557
1985	W	W	13 557	26 626	25 123
1986	W	W	7 937	19 757	27 694
1987[3]	W	W	12 034	15 635	27 669

Sources: Energy, Mines and Resources Canada; Statistics Canada; Company reports.
[1] Ore treated at Sorel; from company reports. [2] Slag with 70 to 72% TiO_2; from company reports. [3] Jan.-Sept.
W Withheld.

TABLE 3. PRODUCTION OF ILMENITE CONCENTRATE BY COUNTRIES, 1983-86

	1983	1984	1985P	1986[e]
		(000 tonnes)		
Australia	906	1 098	1 269	1 315
Canada[1]	635	726	844	844
Norway	544	550	736	771
U.S.S.R.[e]	435	440	445	445
Republic of South Africa	417	417	435	454
United States	W	W	W	W
India	150	150	170	200
Finland	163	167	136	-
China	140	140	140	141
Malaysia	223	195	275	272
Sri Lanka	82	80	100	100
Brazil	48	50	45	45
Total	3 743	4 013	4 595	4 587

Sources: U.S. Bureau of Mines, Minerals Yearbook Preprint, 1983; U.S. Bureau of Mines, Mineral Commodity Summaries, 1986.
[1] Titanium slag containing 70-71% TiO_2 to end of 1983; 80% TiO_2 after 1983.
P Preliminary; [e] Estimated; W Withheld to avoid disclosing company proprietary data.

TABLE 4. PRODUCTION OF RUTILE BY COUNTRIES, 1983-86

	1983	1984P	1985	1986[e]
		(000 tonnes)		
Australia	163	182	204	213
Sierra Leone	72	91	81	91
Republic of South Africa	56	56	55	56
United States	W	W	W	W
Sri Lanka	9	8	8	8
U.S.S.R.[e]	10	10	10	10
India[e]	7	7	7	8
Brazil	1	1	1	1
Total	318	355	366	387

Sources: U.S. Bureau of Mines, Minerals Yearbook Preprint; U.S. Bureau of Mines, Mineral Commodity Summaries.
P Preliminary; [e] Estimated; W Withheld to avoid disclosing company proprietary data.

TABLE 5. TITANIUM SPONGE PRODUCTION AND CAPACITY BY COUNTRIES

	Capacity		Production		
	1985	1986	1984	1985	1986
			(t/y)		
United States	30 400	27 700	22 100	21 100	15 900
Japan	34 500	31 600	15 400	15 400	16 300
United Kingdom	5 000	5 000	2 300	1 400	1 400
China	2 700	2 700	1 800	1 800	1 800
U.S.S.R.	48 000	48 000	41 700	42 600	43 500
Total	120 600	115 000	83 500	82 300	78 900

TABLE 6. LISTED PRICES OF SELECTED TITANIUM COMMODITIES, 1985-87

	1985	1986	1987
Titanium ore, f.o.b. cars Atlantic and Great Lake ports		(A$)	
Rutile, 96% per short ton, delivered within 12 months	510.00-530.00	560-570	560.00-570.00
Ilmenite, 54% per long ton, shiploads	s	s	s
		(US$)	
Titanium sponge, per lb.	5.55-5.85	s	4.00-4.20
Mill products, per lb. delivered			
Billet (Ti - 6AL-4V)	8.35	8.01	7.93
Bar (Ti - 6AL-4V)	9.77	10.06	9.80
Titanium dioxide, anatase[1],			
Bags, 20-ton lots, freight allowed, per lb.	0.69-0.70	0.77-0.79	0.81-0.82
Titanium dioxide, rutile, regular grades, per lb.	0.75	0.81-0.84	0.84-0.86

Source: Metals Week, December.
[1] Chemical Marketing Report, December.
f.o.b. - Free on board; s List price suspended.

Tungsten

D.R. PHILLIPS

SUMMARY

Canada, a major world producer of tungsten contained in ores and concentrates, had no mine production in 1987.

None of the western world mines which closed in 1986 reopened in 1987. As a result, world production of tungsten contained in ores and concentrates was 15% less compared to 1986.

Tungsten prices for ores and concentrates doubled from January through to December but were only 2% higher on average than in 1986, which were the lowest prices during this decade. Prices are expected to double again by 1990 from their average level of US$53.50/t unit for wolframite and US$61/t unit for scheelite in December 1987.

World trade in tungsten ores and concentrates was 8% less than in 1986, mainly due to reduced exports by China.

The consumption of tungsten contained in ores and concentrates is forcasted to return to almost the peak consumption attained in 1980 by the end of this decade.

CANADIAN DEVELOPMENTS

Canada, which normally ranks third as a world producer of tungsten contained in ores and concentrates, had no production in 1987. Canada Tungsten Mining Corporation Limited (Cantung) closed Canada's last producing mine in 1986 due to declining prices. The company continued to ship concentrate from stock in 1987. Cantung also had to close its ammonium paratungstate (APT) plant, located at Fort Madison, IA in March 1987 due to low-priced imports of APT. This APT plant, which was acquired in 1986 by Cantung on the basis of a long term lease from its parent, AMAX Inc., remained closed throughout the rest of 1987.

The 4th International Tungsten Symposium was held in Vancouver, B.C. in September 1987. The symposium was organized by the Primary Tungsten Association (PTA) and the Consumer Reporting Group (CRG), and sponsored by Canada Tungsten Mining Corporation Limited.

It was attended by about 150 delegates from 22 countries. Discussions at the symposium centered on the continued low prices for tungsten and the excess production capacity for tungsten concentrate.

A proposal to form an International Tungsten Industry Association (ITIA) was submitted at the symposium. ITIA is intended to function in a way similiar to other trade associations, with its primary goal to promote additional uses for tungsten. The association would promote tungsten, inter alia, by means of seminars and symposia and would provide a venue for members to exchange ideas.

It has been reported that the first meeting of the group could take place as early as February 1988. Canada Tungsten Mining Corporation Limited had proposed a similar type of organization, The International Tungsten Research Institute (ITRI), at the 3rd International Tungsten Symposium in Madrid in 1985.

Canadian imports of tungsten products in 1987 were estimated at $98 M, an increase of about $28 M in response to increased activity in the mining and metalworking industries.

Tungsten powder was consumed mainly by Macro Division of Kennametal Inc. at Port Coquitlam, B.C., Kennametal Ltd. at Victoria, B.C., Teledyne Canada Firth Sterling Ltd. at Brantford, Ontario and Canada Carboloy Inc., at Toronto, Ontario. Canada Carboloy Inc., previously Canadian General Electric Carboloy Systems, a division of General Electric Canada Inc., was acquired by Seco Tools AB, Sweden in September.

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Small quantities of tungsten wire were consumed by Canadian General Electric at Oakville, and GTE Sylvania Canada Ltd. at Drummondville, Quebec.

Ferrotungsten is mainly consumed by Atlas Steels division of Rio Algom Limited, for the production of specialty steels.

Deloro Stellite Inc. at Belleville, Ontario continued to develop its powder metallurgy (PM) products for use in the pulp and paper, aircraft and medical supplies industries. The company started its PM line in 1985 and is presently operating it at about 70% capacity. It expects to reach full capacity within two years.

The Department of Energy, Mines and Resources has been sponsoring studies to investigate the scope for further processing tungsten concentrates in Canada. This initiative was undertaken because of Canada's prominant mine production, which is exported, and its need to import intermediate and refined products. The studies were initiated in 1986 and are expected to be completed in 1988.

INTERNATIONAL DEVELOPMENTS

All of the major western world producing mines that closed by the end of 1986, due to the tungsten crisis, remained idle during 1987. During 1987, western world mine supply was estimated at 11 800 t of tungsten contained in ores and concentrates, a decrease of 15% compared to 1986. Developing countries accounted for about 70% compared to about 40% in 1986.

The production of tungsten contained in ores and concentrates in the socialist countries of eastern Europe and Asia was estimated at 24 200 t, an increase of 7% compared to 1986.

None of the tungsten mines in North America operated in 1987. Curtis Tungsten Inc., which operated its mine located at Andrew, California for a brief period in 1985, commenced redevelopment of the mine in August 1987. It was reported that the mine could produce about 1 400 t of tungsten in 1988.

The People's Republic of China (PRC) was the world's largest producer of tungsten ore in 1987, followed closely by the U.S.S.R. Mine production in the PRC was reported to be 12 000 t of contained tungsten, a reduction of 22% compared to 1986 and about the same level as in 1983. Mine production in the U.S.S.R. in 1987 was estimated to be 9 000 t of contained tungsten, about the same level as the previous year.

Australian production of tungsten in 1987 was estimated at 1 000 t tungsten content, about 32% less than 1986. All Australian tungsten mines, except the King Island Scheelite mine of Peko-Wallsend Ltd., remained closed in 1987. King Island Scheelite operated at about 29% of capacity during the year.

South Korea, which operated at about 80% of capacity in 1987 and about the same level as 1986, was the third largest producer of tungsten ores and concentrates. Production was estimated at 2 200 t of tungsten.

Austria produced an estimated 1 250 t of tungsten contained in ores and concentrates in 1987, an increase of 4% compared to 1986. This production level represented about 98% of capacity.

Tungsten producers in both Bolivia and Thailand operated at about 26% capacity in 1987. Bolivia's production, estimated at about 900 t of contained tungsten, was a decrease of about 17% compared to 1986. Thailand's production of 425 t of tungsten was about equal to its 1986 output.

Total world supply, including sales by the General Services Administration from the U.S. stockpile and recycled materials, was estimated at 38 000 t of contained tungsten, about 13% less than in 1986.

The consumption of tungsten in the western world was estimated at 18 500 t and in the socialist countries of Asia and eastern Europe at 26 000 t. The difference between global supply and consumption, some 6 500 t, was assumed to be derived from stocks. This deficit is equivalent to 15% of total tungsten consumed in 1987.

Sales of tungsten from the U.S. strategic stockpile in 1987 was estimated at about 700 t, which equalled the amount sold in 1986 and represented about 2% of world supply.

Mine capacity that was built in the late 1970s to take advantage of high prices continued to be a chronic problem. The tungsten industry in the western world, which has operated at about 50% of capacity in recent years, achieved only 35% of capacity in 1987. Although world consumption of tungsten has been maintained in recent years, it is still well below the amount required to absorb all possible production.

WORLD TRADE

Total world trade of tungsten contained in ores and concentrates in 1987 was 41 000 t, a decrease of 8% compared to 1986 and a decline of 21% compared to 1985. Total exports from Asia have declined from 14 000 t in 1985 to 13 000 t in 1986 and to about 8 000 t in 1987.

The decline in exports from Asia was partially due to increased consumption of concentrates by South Korea for the production of ammonium paratungstate (APT). Declining exports of tungsten concentrate from the PRC was partly due to increased exports of APT and tungstic acid instead of concentrates, mainly to the United States, western Europe and, to a lesser degree, Japan, the world's 3 major consumers. The extent of the latter shift is indicated by the rise in the PRC's market share of the U.S. APT market from 3.1% in 1983 to about 17.5% in 1986 and 1987.

In view of the surge in APT imports in the United States, the Refractory Metals Association (RMA) petitioned the U.S. government in 1986 to take action against unfairly traded APT and tungstic acid from the PRC.

In response to the RMA complaint, The United States International Trade Commission (USITC) ruled in May 1987 that imports of APT and tungstic acid from the PRC were injurious to the U.S. tungsten industry. On August 5, 1987, President Reagan directed the United States Trade Representative to negotiate an orderly market agreement (OMA) with the PRC to control imports of APT and tungstic acid, and he further directed that import quotas be imposed if agreement was not reached within 60 days. An agreement was reached with the PRC in September 1987 for a four-year restraint program. It called for an immediate 30% reduction of shipments and allowed for annual increments to bring imports in 1991 up to the 1986 level. APT and tungstic acid imports from the PRC in 1986 were about 2100 t of contained tungsten.

A similar situation was developing in the European Economic Community (EEC). EEC processors of tungsten have been conducting investigations over the past two years to establish whether tungsten products form the PRC were being dumped. In December 1987, press reports indicated that the EEC would charge China with dumping and would proceed with actions to restrict PRC imports unless prices were increased within three months. It was also reported that some European firms would prefer to negotiate an OMA like the one concluded by the United States.

Exports of tungsten contained in ores and concentrates by developing countries were estimated at 6 500 t in 1987, an increase of 1 500 t over 1986 and a decrease of about 500 t compared to 1985.

The developed market economy countries decreased their exports of tungsten contained in ores and concentrates by 1 800 t, a decline of 39% compared to exports by these countries in 1986 and 63% compared to 1985.

Developing countries imported 2 900 t of tungsten contained in ores and concentrates in 1987, which was about the same as 1986. Imports of the developed market economy countries increased by 1 000 t in 1987 to about 9 500 t, but about 3 000 t less than imports in 1985. The socialist countries of eastern Europe imported 10 500 t, which was the same amount as in 1986 and about 1 000 t more compared to 1985.

A revised U.S. Bill, which is intended for incorporation in the Senate Trade Bill (S. 1420) and calls for the suspension of the 17¢/lb. tariff on imported tungsten contained in ores and concentrates, was tabled in April for debate in the Senate. The Bill was referred to the Senate Finance Committee in October for further study to permit quick passage.

INTERNATIONAL ORGANIZATIONS

UNCTAD - Committee on Tungsten

International discussions on market developments and the scope for stabilizing the tungsten market were held at the 19th Session of the United Nations Committee on Tungsten (COT) in Geneva on November 9-13, 1987. The dialogue at the 19th Session centered on four issues:

(i) Reasons for the depressed conditions of tungsten markets and ways of increasing transparency of complex international markets for tungsten concentrate and intermediate products.

(ii) Involvement of the COT in research and development programs as an aid to strengthening markets.

(iii) Price Stabilization.

(iv) Statistical Issues including the adoption of a new format by the United Kingdom (U.K.) for collecting statistics on intermediate products.

Most of the delegates attending the 19th session agreed that the increase in price from its catastrophic low of US$30/t unit (tu) in 1986 to about US$60 in 1987 was below the production cost of most mines.

The Secretary of the Primary Tungsten Association (PTA) announced that the PTA would be dissolved at the end of December 1987. The PTA is comprised of producers in Australia, Bolivia, Brazil, Peru, France, Portugal, Romania, Zaire and Sweden. Representatives of China Minerals and Metals Import and Export Corp. (Minmetals) and Cantung have attended some PTA meetings as observers. The Secretary also gave a presentation on the proposal for the International Tungsten Industry Association, which would, to some extent, take the place of the PTA.

PRICES

After a short-term recovery and reaching a temporary high in November 1987, prices reversed and fell slightly during December. The quoted price for scheelite concentrate increased from US$46.00/tu in January 1987 to US$65.00 in November. Wolframite concentrate increased in price during the same period from US$35.25/tu to US$53.00.

Prices reported by the Metal Bulletin (MB) and by the International Tungsten Indicator (ITI) for the months January, July and December 1987 are summarized as follows:

	MB		ITI
	Wolframite	Scheelite	Tungsten Concentrate[1]
	(US$/tu[2] WO_3)		
Jan.	35.25-46.00	46.00-55.00	43.11-46.09
July	48.00-57.00	55.00-61.00	53.69-56.21
Dec.	49.00-58.00	57.00-65.00	53.52-56.44

[1] Concentrate price based on an average WO_3 content related to monthly transactions.
[2] One tonne unit (tu) of WO^3 contains 7.93 kilograms of tungsten.

Major factors contributing to these price increases were actions taken by the PRC and the United States.

The PRC, the world's largest producer and trader, restricted authorization for the exports of tungsten to China Minerals and Metals Import and Export Corp. (Minmetals) and China National Nonferrous Metals Import and Export Corporation (CNIEC). Exports sales had previously been arranged by various sources. In addition, the PRC established a minimum price of $50 for wolframite, $60 for scheelite and $70 for APT.

Reports in China's Non-Ferrous News also claimed that the PRC's main tungsten mines in Jiangxi, Hunan and Guangdong had reduced their output, compared to 1986, as an aid to reducing stock levels.

In the United States, the General Services Administration announced in March it would no longer sell tungsten contained in ores and concentrates from the U.S. strategic stockpile. Sales of tungsten were terminated because the total value of sales of all materials from the stockpile had exceeded the authorized limit. Sales were resumed in October.

The decision by President Reagan that called for the USTR to negotiate an Orderly Marketing Agreement with the PRC for imports of APT and tungstic acid and the subsequent agreement in September to reduce imports was also a factor in the price increases.

USES

Approximately 80% of the western world tungsten consumption in 1986 was accounted for in the manufacture of cemented carbide and tool steel products, the former amounting to approximately 50% of total consumption. Tungsten metal, superalloys and miscellaneous end-uses accounted for the remaining 20%.

Major consumers of tungsten include the oil and gas, mining, manufacturing and farm equipment industries.

Tungsten materials can be divided into several major classes, depending upon the product form and its use. The main product forms include tungsten carbide, tungsten-bearing steels, superalloys, mill products made essentially from pure metal, and chemicals.

Tungsten carbide (WC) is one of the hardest materials known and, accordingly, has widespread applications where intense wear and abrasion are encountered. This product is the preferred metalworking material for the cutting edges of machine tools and as a metal surface in forming and shaping dies. It is produced by the chemical combination of tungsten metal powder and finely divided carbon. Tungsten carbide is compacted to the desired form, using cobalt as a binder, and sintered to produce cemented tungsten carbide. Cutting tools of cemented tungsten carbide are used for machining steel, cast iron and nonferrous metals, and for shaping in the woodworking and plastics industries. Cemented tungsten carbide is also used to make dies for wire and tube drawing, punches and dies for metal forming, and bits and tools for drilling equipment and wear-resistant parts. With the addition of tantalum, titanium and columbium carbides, the coefficient of friction of cemented tungsten carbides is lowered, thereby producing grades better suited to the machining of specific items, particularly steel products. Other uses of tungsten carbide are in tire studs, spikes for golf shoes, armour-piercing projectiles and welding electrodes.

As an alloy constituent, tungsten is used primarily in the production of high-speed steels, and tool and die steels. Tungsten is added to steels either as ferrotungsten (80% tungsten), melting base (30-35% tungsten), scheelite ($CaWO_4$) or as tungsten-bearing scrap. Tungsten-bearing steels are used for the same applications as carbides, especially where lower operating temperatures are encountered. Tungsten is also used in some stainless steels for applications in high-temperature environments.

Tungsten is an important constitutent in a wide variety of superalloys and nonferrous alloys. Tungsten-containing superalloys are being used increasingly in high-temperature applications and in highly corrosive environments because of their high-temperature strength and oxidation resistance. In making the alloys, tungsten is usually added in the form of metal powder, although scrap can be used to satisfy part of the requirements. Superalloys can be classified into three principal types: nickel base, iron base and cobalt base (stellite) superalloys. While only small amounts of tungsten are currently used in the nickel and iron base superalloys, several companies are developing new superalloys containing larger amounts of tungsten, a factor which could significantly expand the market for tungsten.

Mill products made from pure or nearly pure tungsten metal powder are used in significant quantities by the electrical industries. The relevant important properties of tungsten for electrical applications include its high-melting point, low-vapour pressure, hardness, good electrical conductivity and low coefficient of thermal expansion. Tungsten mill products such as rods, wire and flat products are made by compressing tungsten metal powder into the desired shape and then sintering.

Discs cut from tungsten rods are used as electrical contacts to improve resistance to heat deformation resulting from sparking and associated high temperatures. Tungsten discs are also used as heat sinks in semiconductor applications and, in combination with other elements, as electrical contacts and breakers for industrial use.

Tungsten wire is used for filaments in incandescent lamps, and heating elements in both fluorescent lamps and vacuum tubes. The overall demand for tungsten wire is increasing in response to the upward trend in the manufacture of lamps and new uses such as de-icing and defogging elements in automobile glass.

Flat products are used for various parts of electron tubes and radiation shields as well as for very high-temperature applications in reducing or inert atmospheres.

Tungsten is used for counterweights and balances, especially by the aircraft industry, and it is replacing depleted uranium, which has about the same density, in similar applications.

Minor amounts of tungsten are used to make chemicals and compounds for nonmetallurgical applications. Some of the end-uses include dyes, chemical reagents, catalysts, lubricants, paints and varnishes.

OUTLOOK

Prices for tungsten contained in ores and concentrates are forcasted to rise over the next three years, increasing from a current range of US$60-65/tu to US$90-100/tu by 1990. An increased demand for ores and concentrates is expected to take place in the major consuming countries: the United States, Japan, western Europe and the PRC.

The consumption of tungsten in the PRC is expected to grow because of decentralization, which is forecasted to lead to escalated development, expansion and modernization of China's industrial sector up to the year 2000. This increase in demand is also projected to result in a further reduction in exports of tungsten products from the PRC. In this regard, it has been reported that China may not seek to increase tungsten exports, one of its major exported materials, as a means of securing hard currency in the future.

The increased consumption in the United States and western Europe is based on a recovery in the mining and industrial sectors, reduced recycling, and the substitution of tungsten for molybdenum in tool steels and for uranium in counter weights and military applications.

Recycling is closely related to the price of primary tungsten. It is generally not considered profitable while the price of primary tungsten is below US$90/tu. Accordingly, recycling is currently at a low level and will probably stay stable for the next two years.

The prior replacement of molybdenum for tungsten in tool steel occurred when tungsten prices were considerably higher than US$90. For the same reason it is expected that tungsten could be resubstituted for molybdenum. Although price is a consideration, tungsten is expected to replace uranium in the production of counter weights, balancing and military applications mainly because of technical and environmental reasons.

If prices continue to increase in 1988, some mines that closed in 1986 might reopen and total mining could operate at about 65% of capacity. This situation could continue through to 1990. Total mine output, recycled material and releases from the U.S. stockpile are forcasted to rise by about 10 000 t/y to 46 000 t/y by the end of this period.

Consumption is forcasted at 48 000 t and 49 500 t in 1989 and 1990 respectively, which is sufficient to keep supply and demand in balance during these years.

PRICES

	December 1986 Week Ending 26th	December 1987 Week Ending 11th
	(US$)	
Tungsten ore, 65% minimum WO_3		
G.S.A. domestic, duty excluded, per short ton unit of WO_3	32.00-42.769	31.35
G.S.A. export, per short ton unit of WO_3	61.25	N.Q.
L.M.B. ore quoted by "London Metal Bulletin" c.i.f. Europe, per tonne unit of WO_3	31.00-45.00	48.00-58.00
MW U.S. spot ore, per short ton unit	30.00-37.00	48.00-56.00

Source: Metals Week.
c.i.f. Cost, insurance and freight; N.Q. Not quoted.

TABLE 1. CANADA, TUNGSTEN PRODUCTION, CONSUMPTION AND IMPORTS, 1985-87

	1985^r		1986^p		1987^e	
	(kilograms)	($000)	(kilograms)	($000)	(kilograms)	($000)
Production[1] (WO_3)	4 030 574	..	2 469 990	..	-	..
Consumption[2] (W content)						
Tungsten metal and metal powder	693 829	..	632 927	..	675 000	..
Other tungsten products[3]	13 442	..	14 212	..	15 500	..
Total	707 271	..	647 139	..	690 500	..
Imports						
Tungsten in ores and concentrates						
United States	10 000	121	10 000	73	10 000	69
People's Republic of China	1 000	14	1 000	17	-	-
Total	11 000	135	11 000	90	10 000	69
Ferrotungsten[4]						
United States	1 000	39	7 000	115	8 000	96
Other	-	-	0	0	-	-
Total	1 000	39	7 000	122	8 000	96
Tungsten carbide powder						
United States	238 997	7 012	217 634	5 964	154 700	3 900
Other countries	21 227	504	44 996	1 396	45 500	1 200
Total	260 224	7 516	262 720	7 360	200 200	5 100
	(number)	($)	(number)	($)	(number)	($)
Tungsten carbide rotary rock drill bits						
United States	15 346	58 970	7 002	31 513	14 300	61 500
Other countries	1 400	6 353	914	4 333	620	5 500
Total	16 746	65 323	7 916	35 846	14 920	67 100
Tungsten carbide percussion rock drill bits						
Ireland	83 265	1 194	120 406	2 201	115 000	1 950
United States	80 055	2 555	107 513	2 065	95 000	1 875
Sweden	33 777	623	29 185	931	32 000	1 007
Other countries	12 478	678	6 036	713	10 000	857
Total	209 567	5 050	263 055	5 804	252 000	5 689
Tungsten carbide tools for metal work						
United States	..	11 245	..	14 300	..	13 700
Other countries	..	3 311	..	6 147	..	6 200
Total	..	14 556	..	20 447	..	19 900

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Producers' shipments. [2] Available data as reported by consumers. [3] Includes tungsten ore, tungsten carbide and tungsten wire. [4] Gross weight.
^{p} Preliminary; ^{r} Revised; ^{e} Estimated; - Nil; .. Not available.

TABLE 2. CANADA, TUNGSTEN PRODUCTION, TRADE AND CONSUMPTION, 1975 AND 1979-87

	Production[1]	Imports		Consumption[2]
		Tungsten Ore[2]	Ferrotungsten[3]	
	(kilograms)			
1975	1 477 731	1 000	45 359	451 336
1979	3 254 000	11 000	28 000	380 229
1980	4 007 000	6 000	7 000	290 479
1981	2 515 000	14 000	6 000	401 447
1982	3 029 730	7 620	4 536	485 606^{r}
1983	1 537 880	12 000	3 000	503 651
1984	4 195 785	6 000	5 000	659 665
1985^{r}	4 030 547	11 000	1 000	707 271
1986P	2 469 990	11 000	7 000	647 139
1987^{e}	-	10 000	8 000	690 500

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Producers' shipments of scheelite (WO_3 content); [2] W content, available data as reported by consumers; [3] Gross weight.

P Preliminary; ^{r} Revised; ^{e} Estimated.

- Nil.

TABLE 3. WESTERN WORLD COUNTRIES, 1987 MINE CAPACITY AND UTILIZATION, AND 1990 FORECASTED CAPACITY

	1987 Capacity^{e}	1987 % Utilization[1]	1990 Capacity^{e}
	(tonnes W content)		
Canada	3 900^{r}	0	6 440
United States	2 500^{r}	0	3 500
Bolivia	3 500	26	3 550
Brazil	1 280	55	1 280
Austria	1 600	98	1 600
France	840	0	840
Portugal	1 570	95	1 570
Spain	460	15	460
Sweden	400	93	400
United Kingdom	75	..	75
South Africa	420	..	1 130
Japan	700	39	500
South Korea	2 800	79	2 800
Thailand	1 750	26	1 750
Turkey	1 000	5	1 000
Australia	3 400	29	3 400

Sources: USBM Mineral Commodity Summaries, 1985; Energy, Mines and Resources Canada.

[1] Per cent utilization calculated.

^{e} Estimated; ^{r} Revised; .. Not available.

TABLE 4. WORLD TOTAL SUPPLY AND CONSUMPTION OF TUNGSTEN AND AVERAGE ANNUAL WOLFRAM PRICE, 1980-90

Year	Production	Recycled	GSA, Sales	Total Supply	Consumption	Surplus (Deficit)		Wolfram Average Annual Price
						Annual	Accumulated	
				(t,W)				(US$/t Unit)
1980	50 323	..	1 703	52 026	49 149	2 877	2 877	142.55
1981	48 701	..	958	49 659	47 095	2 564	5 441	143.20
1982	45 432	2 977	363	48 772	40 562	8 210	13 651	111.78
1983	38 310	3 072	608	41 990	40 770	1 220	14 871	81.86
1984	43 627	3 998	1 488	49 113	48 487	626	15 497	80.75
1985	46 000	1 287	694	47 981	46 457	1 524	17 021	68.40
1986	41 900	1 230	500	43 630	44 500	(870)	16 151	47.56
1987ᵉ	36 020	1 230	700	37 950	44 500	(6 550)	9 601	48.19
1988ᵉ	41 140	1 500	500	43 140	46 000	(2 860)	6 740	80.00
1989ᵉ	46 260	1 500	600	48 360	48 000	360	7 100	85.00
1990ᵉ	46 000	2 760	600	49 360	49 000	360	7 460	95.00

Sources: United Nations Conference on Trade and Development, Tungsten Statistics; Metal Bulletin; Energy, Mines and Resources Canada.
ᵉ Estimated; .. Not available.

Uranium

R.T. WHILLANS

OVERVIEW

Prospects for the Canadian uranium industry improved late in 1987 with the announcements of the proposed Canada-United States Free Trade Agreement (FTA) and a new Canadian policy on foreign ownership in the uranium mining sector.

The FTA would alleviate some of the uncertainty that has grown about possible U.S. court or legislative action to ban foreign uranium imports for enrichment and domestic use. In principle, the United States has agreed to "exempt Canada from any restriction on the enrichment of foreign uranium under Section 161v of the [US] Atomic Energy Act," and Canada has agreed to "exempt the United States of America from the Canadian Uranium Upgrading Policy as announced by the Minister of State for Mines on October 18, 1985". The FTA, signed on January 2, 1988, requires enabling legislation to be passed before it can be ratified by both countries.

Canada's new policy on foreign ownership was announced on December 23, 1987. It specifies that Canadians must own at least 51% of an individual uranium property when production begins. If a project is Canadian-controlled, a reduction from the 51% level may be permitted. Only in cases where Canadian partners cannot be found would exemptions to the policy be considered, and these would require special Cabinet approval. The new policy is designed to encourage investment in Canada's uranium mining industry, and to promote economic development, exports and jobs for Canadians.

Progress on several uranium projects gave the industry needed encouragement in 1987: in Saskatchewan, Cigar Lake Mining Corporation (CLMC) received approval to proceed with its test mine; Denison Mines Limited and a partner acquired 60% of the Midwest Lake project; and in the Northwest Territories, Urangesellschaft Canada Limited is examining the possibility of production at its Kiggavik (formerly Lone Gull) project.

In February 1987, the government of British Columbia allowed the seven year moratorium on uranium exploration and mining to lapse. Uranium exploration is unlikely to resume in the near term, as stringent new regulations may continue to dampen provincial uranium developments.

The federal and Saskatchewan governments continued their efforts toward the privatization of their respective Crown corporations, Eldorado Nuclear Limited and Saskatchewan Mining Development Corporation (SMDC).

Canada maintained its position as the world's leading producer and exporter of uranium in 1987; output and exports each exceeded the five-year highs of 1986. With a large share of the world's uranium resources of economic interest, Canada remains the international focus of uranium exploration activity.

Uranium exploration expenditures were expected to reach $36 million in 1987, due in part to the low uranium discovery costs in Canada. In 1985 dollar terms, the cost of uranium discovery from 1971 to 1983 averaged $2.60/kgU for the country as a whole and $1.53/kgU in Saskatchewan. The Athabasca Basin in northern Saskatchewan is the principal target for the discovery of very high-grade, low-cost, uranium deposits.

PRODUCTION AND DEVELOPMENT

In 1987, Canada's five primary uranium producers reported concentrate output totalling some 12 450 tU, up for the second consecutive year. Figure 1 locates these five existing producers and Canada's major uranium deposits. Based solely on existing operations, Canada's annual production capability is expected to continue at the 12 000 tU level through the mid-1990s.

Over the past several years, the stagnation of uranium prices and the sustained upward pressure on production

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costs have led to reductions in Canada's uranium industry workforce. At the end of 1986, some 5100 employees worked at the country's seven producing uranium operations, a drop of 13% from the 1984 level. Table 1 summarizes recent output and employment data for Canada's uranium producers.

Canada's total uranium shipments remain high, as shown in Table 2; the preliminary estimate of the value of the 1987 shipments exceeds $1 121 million. As requirements for domestic reactors are only about 15% of current output, most of Canada's uranium production is available for export.

Athabasca Basin, Saskatchewan

At the Rabbit Lake operation, Eldorado Resources Limited met its 1987 production objectives for the Collins Bay B-zone orebody. Anticipating depletion of the B-zone in the early 1990s, Eldorado submitted an Environmental Impact Statement for regulatory approval to develop its Collins Bay A and D orebodies, and to initiate underground exploration and test mining at the Eagle Point deposit. Environmental approval by the province was anticipated early in 1988.

In March 1987, Cluff Mining started recovering gold and uranium from reprocessed Phase I leach residues; the first gold bar was poured in April. Output of uranium for 1987 met delivery commitments, but was below nominal capacity. Production comes from the Claude open pit and the Dominique-Peter underground mine.

A new output record was set in 1987 by Key Lake Mining Corporation (KLMC), which again surpassed its nominal mill capacity of 4 600 tU. The Gaertner pit was mined out in late 1986 and is being allowed to flood. Current efforts are concentrated on preparing the larger Deilmann orebody for mining in mid-1988. KLMC conducted a 10 000-tonne heap-leach test in the summer to verify uranium extraction rates from the lower-grade cobble ore; a 100 000-tonne facility was planned for possible operation in 1988.

Elliot Lake, Ontario

Early in 1987, Denison Mines Limited acquired the claims of Canuc Resources Inc., located just southwest of its main mine. Development of a conveyor access is under way to permit resource exploitation in the future. With output levels more in line with contract commitments, Denison will continue its measures to reduce operating costs and improve productivity.

In 1986, Rio Algom Limited renegotiated its uranium supply agreement with Ontario Hydro. The higher-grade deposits at its adjoining Nordic, Milliken, and Lacnor properties are being developed as part of the overall effort to increase productivity and decrease costs. Rio Algom reported lower earnings due mainly to a 19-day strike in the fall, and to reduced deliveries to Ontario Hydro.

The key 1986 operational characteristics of Canada's existing uranium producers are presented in Table 3.

EXPLORATION

In 1987, EMR's Uranium Resource Appraisal Group (URAG) completed its thirteenth annual uranium supply assessment and survey of exploration activity. The results were reported[1] late in 1987. Table 4 summarizes uranium exploration activity in Canada from 1976 to 1986.

The high grade and low discovery cost of Saskatchewan uranium deposits attracts exploration dollars. As Table 5 reveals, discovery costs in Canada for the period 1971 to 1983 were $2.60/kgU for the country as a whole, $1.53/kgU for Saskatchewan alone, and $13.58/kgU for Canada excluding Saskatchewan.

Exploration expenditures rose modestly in 1986 to $33 million and could reach $36 million in 1987, a trend that the industry hopes will continue. Exploration drilling decreased in 1986 as work was concentrated on established properties with proven resources. In eastern Canada and the Northwest Territories, grassroots exploration expanded into new areas. The on-going effort in northern Saskatchewan, where 90% of the national effort is expended, may lead to the discovery of important new uranium deposits. Extensions to the Eagle Point orebody serve as the most recent example.

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[1] "Canada's Uranium Resource Estimates Increase" - News Release 87/224, EMR Canada, September 4, 1987.

The 10 most active operators[1] in 1986 spent 97% of the $33 million total expenditure. In alphabetical order they were: Amok Ltd., CEGB Exploration (Canada) Ltd., Cigar Lake Mining Corporation, Cogema Canada Limited, Eldor Resources Limited, Minatco Ltd., PNC Exploration (Canada) Co. Ltd., Saskatchewan Mining Development Corporation, Uranerz Exploration and Mining Limited, and Urangesellschaft Canada Limited. As shown in Figure 2, non-U.S. foreign-based firms accounted for 55% of the 1986 expenditures in Canada, twice the level of 1981. Canadian firms spent about 44% of total, while U.S. companies virtually ceased participating.

CLMC was granted an underground exploration permit in August, and environmental approval in October, to proceed with its $40 million test mine at Cigar Lake, in north-eastern Saskatchewan. The 490m-deep shaft was under way at year-end and shaft sinking is to be completed in 1988. Drifting for the underground mining test should be finished in 1989. If final approval is received in 1991, production could begin in 1993. Output is expected to be about 4 600 tU annually.

In August, Denison Mines Limited and a partner acquired a 60% working interest in the Midwest Lake project, north of Cigar Lake, for $12 million. Esso Resources Canada Limited and Numac Oil & Gas Ltd. sold the partnership 50% and 10%, respectively. As project manager, Denison is assessing the possibility of production in the mid-1990s. Reported drill-indicated resources exceed 20 000 tU in ore grading 1.1% U.

Urangesellschaft Canada Limited continued work at its Kiggavik (formerly Lone Gull) project, near Baker Lake in the Northwest Territories, following an encouraging 1986 pre-feasibility study. If a production decision is made, annual output of 1 400 tU could be envisaged from the $200 million project, perhaps by the mid-1990s. Diluted reserves exceed 15 000 tU in ore grading 0.4% U.

RESOURCES

The results of the 1986 URAG assessment of Canadian uranium resources, which reflect continued successes in uranium exploration and development effort, are shown in Table 6 with the 1984 results[1].

Known resources at the end of 1986 were 567 000 tU, up from the 551 000 tU reported for 1984. New discoveries more than made up for the 23 000 tU produced in 1985 and 1986, and for the elimination of some higher-cost resources from the overall estimates.

To provide an illustration of uranium availability in the short term, two projections of Canadian production capability are presented in Figure 3. The scenarios show firm production capability based only on existing operations that rely solely on measured, indicated, and inferred resources. The upper curve shows production levels achievable under current circumstances using "A" + "B" priced resources; the lower curve is based on "A" priced resources alone.

In certain cases, the lives of these production centres could be extended by the exploitation of associated higher-cost resources, or through additions of resources in the "A" and/or "B" price categories. Growth in the uranium market could also lead to the development of new production capability beyond 15 000 tU annually by the mid-1990s.

UNITED STATES INITIATIVES

On July 20, a U.S. Court of Appeals upheld a June 1986 order made by Judge Carrigan of the U.S. Tenth Circuit Court in Denver, which would place a total restriction on the enrichment by the U.S. Department of Energy (DOE) of foreign uranium for domestic use, effective January 1, 1987. A stay on this order had been granted by the Appeals Court pending its review of the case. Upon receiving the Appeals Court decision, the DOE filed for another stay, which was granted by the Appeals Court on October 8, 1987. It gave the DOE time to file a petition for writ of **certiorari** to the Supreme Court. The writ was filed on October 18 and in early January 1988, the Supreme Court decided to hear the case. The stay will continue until final disposition by the Supreme Court.

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[1] In certain cases, the identified operator has reported the total expenditures of a joint-venture effort. Therefore, contributions by other parties not responding to the URAG survey are accounted for in the $33 million total.

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[1] "Uranium in Canada: 1984 Assessment of Supply and Requirements," Report EP 85-3, EMR Canada, September 1985.

From 1967 to 1984, international uranium markets were disrupted when the U.S. uranium industry first received protection under Section 161v of the Atomic Energy Act. In 1987, non-U.S. producers feared that the world's largest uncommitted uranium market might again be closed by the reintroduction of U.S. restrictions on the enrichment of foreign uranium for domestic use. Canada would be the supplier most adversely affected by such restrictions, as one-third of the uranium exported from Canada is destined for U.S. power utilities. Annual Canadian uranium sales to the United States are valued at about $300 million. The Free Trade Agreement with the United States would remove the threat of a renewal of import restrictions on Canadian uranium.

MARKETS AND PRICES

As shown in Table 7, Canada has maintained its position as the world's leading producer of uranium. Despite the uncertainty prevailing in world markets, Canadian producers negotiated sales in 1987 for more than 6 000 tU. Table 8 indicates the total amount of uranium under export contracts approved since 1974. As of January 1988, forward commitments under the 40-odd Canadian export contracts and the handful of domestic contracts exceeded 57 000 tU and 72 000 tU, respectively.

The average price of Canadian export deliveries in 1986 was about $89/kgU, as shown in Table 9. It slipped to $79/kgU in 1987, largely due to a significant increase in spot deliveries during the year. Of the total quantities delivered, 35% was attributable to spot sales, compared with only 21% in 1986. However, when viewed separately, the declines in spot-sale and long-term contract prices were less marked; indeed, in terms of U.S. dollars they were about the same as in 1986.

Uranium spot market prices remained significantly lower compared to Canada's average export price. The Nuclear Exchange Corporation (Nuexco) monthly exchange value[1] hovered between US$16.65 and $17.00/lb. U_3O_8 throughout most of 1987, settling at $16.55/lb. by year end.

In 1987, actual exports exceeded 12 000 tU, almost matching production. Table 10 summarizes exports of Canadian origin uranium from 1982 to 1986 for each of Canada's principal export customers.

Tables 11 and 12 tabulate the value of Canadian exports of Radioactive Ores and Concentrates and Radioactive Elements and Isotopes reported by Statistics Canada. The future importance of Canada's export markets is illustrated in Figure 4 in terms of forward scheduled deliveries of uranium in concentrates.

In August, SMDC announced agreements with the Korea Electric Power Corporation (KEPCO) providing for the sale to KEPCO of a 2% non-voting interest in the Cigar Lake project for $8 million. The sale is the first approved under the federal government's new foreign ownership policy. Associated with the equity transaction is a long-term uranium supply contract with KEPCO, worth about $150 million, which provides for the delivery of 170 tU annually from 1993 to 2002, and a possible extension to 2012. Financing and development of the Cigar Lake project will be greatly assisted by this sale, which is seen as a significant commitment toward future production.

REFINING

Eldorado Resources Limited operates the only uranium refining and conversion facilities in Canada, located at Blind River and Port Hope, Ontario, respectively. In 1986, Eldorado processed record volumes of mine concentrates containing some 8 240 tU. This represented a 21% increase over 1985, due largely to greater export opportunities for uranium hexafluoride (UF_6). Production of uranium dioxide (UO_2) for use in CANDU reactors contributed as well, following the start-up of new reactors at Ontario Hydro's Pickering and Bruce nuclear generating stations. The higher UF_6 and UO_2 output levels resulted in lower unit production costs at both the refinery and conversion facilities during 1986, the first full year of operation following Eldorado's plant expansions.

NUCLEAR POWER DEVELOPMENTS

In 1987, nuclear generating capacity increased worldwide by about 8%, as 21 new reactors came on line in eight countries. The International Atomic Energy Agency (IAEA) reported that as of January 1, 1988, some 416 nuclear power reactors were operable, with a combined generating capacity in excess of 295 gigawatts electric (GWe), producing about 16% of the world's total electrical power. The IAEA had projected in 1986 that installed nuclear generating capacity would increase by 28% from 1986 to 1990 and by 16% from 1990 to 2000.

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[1] The price at which transactions for significant quantities of natural uranium concentrates could be concluded as of the last day of the month according to Nuclear Exchange Corporation (Nuexco), a California-based uranium brokerage firm.

At the end of 1987, 18 commercial CANDU reactors with an aggregate output capacity of some 12 000 megawatts (MWe) were in service in Canada, as shown in Table 13; four additional reactors under construction in 1987 will enter service between 1988 and 1992, contributing 3 500 MWe to the Ontario Hydro grid. Over 15% of Canada's electric power was nuclear-generated in 1987, while in Ontario it was half.

CANDU reactors continue to maintain their standing among the world's best performers. As of June 30, 1987, seven CANDUs in Canada were in the top 10 in terms of lifetime operation, out of some 250 commercial power reactors of 500 MWe size or greater in service worldwide.

OUTLOOK

The outlook for Canada's uranium industry brightened considerably in 1987. The Free Trade Agreement (FTA), signed by the United States and Canada and expected to be ratified by both governments in 1988, would ensure access to the U.S. uranium market, which is the largest in terms of uncommitted demand. In the near and medium term, this market is crucial to Canada's uranium producers.

Canada's new policy on foreign ownership in the uranium mining sector will promote economic development, jobs for Canadians, and uranium exports by providing more flexibility for investors wishing to develop the uranium deposits discovered in Canada in recent years.

Canada has the resources and the experience to meet all of its delivery commitments. Based solely on existing operations, annual production capability is expected to continue at some 12 000 tU through the mid-1990s. Given some growth in the uranium market, the development of new production capability beyond 15 000 tU per year could be achieved by the mid-1990s.

Currently accounting for about one-third of western world supply, Canada will be able to provide for its own modest needs and contribute to those of its trading partners for decades to come.

TABLE 1. URANIUM PRODUCTION IN CANADA AND WORK FORCE SUMMARY, 1985 AND 1986

Province and Producer	Total Work Force (Dec. 31) 1986	Total Work Force (Dec. 31) 1985	Annual Output (tU) 1986	Annual Output (tU) 1985
Athabasca Basin, Saskatchewan:				
Key Lake Mining Corporation	425	413	4 834	4 270
Eldorado Resources Limited	376	340	1 227	824
Cluff Mining	220	281	834	834
Sub-total	1 021	1 034	6 895	5 928
Elliot Lake, Ontario:				
Denison Mines Limited	1 737	1 870	2 015	2 112
Rio Algom Limited				
- Quirke	1 132	1 026	1 259	1 328
- Panel	653	685	886	827
- Stanleigh	537	718	668	685
Sub-total	4 059	4 299	4 828	4 952
Total	5 080	5 333	11 723	10 880

TABLE 2. VALUE OF URANIUM SHIPMENTS[1] BY PROVINCE, 1984-87

	1984	1985	1986	1987P
Ontario producer shipments (tU)	4 552	4 499	4 752	4 364
Value of shipments ($ million)	545	553	566	509
Saskatchewan producer shipments (tU)	5 720	5 942	6 750	8 838
Value of shipments ($ million)	357	450	476	612
Total producer shipments (tU)	10 272	10 441	11 502	13 202
Total value of shipments ($ million)	902	1 002	1 042	1 121

[1] Shipments in tonnes of uranium (tU), contained in concentrate, from ore processing plants.
P Preliminary.

TABLE 3. OPERATIONAL CHARACTERISTICS OF EXISTING CANADIAN URANIUM PRODUCTION CENTRES, 1986

	Ore-processing Plant			
	Capacity	Recovery	Annual Throughput	
Company/Facility Name	Nameplate/ Actual (t/d)	Overall (%)	Ore Total (t)	Ore Grade (% U)
Cluff Mining/Cluff Lake	>800/ 750	98	213 176	0.40
Denison Mines Limited/Elliot Lake	13 600/7 700	93	2 550 100	0.08
Eldorado Resources Limited/Rabbit Lake	1 800/1 940	85	320 600	0.46
Key Lake Mining Corporation/Key Lake	700/ >700	98	248 530	1.96
Rio Algom Limited/Elliot Lake				
- Quirke	4 990/4 960	94	1 656 000	0.08
- Panel	2 990/3 000	96	981 860	0.10
- Stanleigh	4 540/3 270	94	1 178 180	0.07

Sources: Corporate annual reports and the Atomic Energy Control Board (AECB).

TABLE 4. URANIUM EXPLORATION ACTIVITY IN CANADA, 1976-86

Year	Expenditures[1] ($ million)	Drilling[2] (km)	Million Dollar Projects[3]
1976	44	155	4
1978	90	334	7
1980	128	503	24
1982	71	247	13
1984	35	197	12
1986	33	162	11

[1] Direct exploration and drilling expenditures in current dollars. [2] Exploration and surface development drilling; excludes development on producing properties. [3] Number of projects where direct exploration and drilling expenditures exceeded $1 million in current dollars.

TABLE 5. CANADIAN URANIUM DISCOVERY COSTS FROM 1971-83[1] ($ 1985)

	Exploration Expenditures ($ million)	Uranium Discovered (tU)	Cost/kgU ($)
Total Canada	1 096	421 200	2.60
Saskatchewan	588	383 800	1.53
Canada excluding Saskatchewan	508	37 400	13.58

[1] From a paper by D.A. Cranstone and R.T. Whillans entitled "An Analysis of Uranium Discovery Costs in Canada, 1930-1983" presented at an International Atomic Energy Agency-sponsored Technical Committee Meeting on Uranium Resources and Geology of North America, Saskatoon, Saskatchewan, August 31-September 4, 1987.

TABLE 6. ESTIMATES OF CANADA'S URANIUM RESOURCES RECOVERABLE FROM MINEABLE ORE[1], 1984 AND 1986

Price Ranges Within Which Mineable Ore is Assessed[2]	Measured		Indicated		Inferred	
	1986	1984	1986	1984	1986	1984
			(000 tonnes U)			
A	46	31	107	124	112	105
B	1	-	95	59	99	[illegible]
A + B	47	31	202	183	211	197
C	23	23	33	50	51	67
A + B + C	70	54	235	233	262	264

[1] Actual or expected losses in mining recovery and ore processing have been accounted for; these factors were individually applied to resources tributary to existing or prospective production centres. In underground operations, mineable ore is generally 75 to 85% of the ore-in-place; higher mining recoveries are achievable in open-pit operations. Ore-processing recoveries in Canada normally range from 90 to 97%; the 1986 weighted average mill recovery of Canada's existing conventional uranium operations was 96%. [2] The price ranges are (A) $100/kgU or less, (B) between $100 and $150/kgU and (C) between $150 and $300/kgU. The Canadian dollar figures reflect the price of a quantity of uranium concentrate containing 1 kg of elemental uranium. The prices were used in determining the cut-off grade at each deposit assessed, taking into account the mining method used and the processing losses expected. The price of $100/kgU was used by URAG to illustrate those resources that were of economic interest to Canada in 1986.
- Nil.
Note: $1/lb. U_3O_8 = $2.6/kgU.

TABLE 7. PRODUCTION OF URANIUM IN CONCENTRATES BY MAJOR PRODUCING COUNTRIES, 1981-86

	1981	1982	1983	1984	1985	1986
			(tonnes U)			
Canada	7 720	8 080	7 140	11 170	10 880	11 720
United States	14 800	10 330	8 140	5 720	4 350	5 200
South Africa	6 130	5 820	6 060	5 740	4 880	4 610
Namibia	3 970	3 780	3 720	3 690	3 600	3 300
Australia	2 920	4 420	3 210	4 390	3 250	4 150
Niger	4 360	4 260	3 470	3 400	3 180	3 110
France	2 560	2 860	3 270	3 170	3 200	3 250
Gabon	1 020	970	1 040	1 000	940	900
Other[1]	670	970	900	950	900	870
Total[2]	44 150	41 490	36 950	39 230	35 180	37 110

Sources: "Uranium: Resources, Production and Demand," a report jointly produced by the Nuclear Energy Agency of the OECD and the International Atomic Energy Agency, and miscellaneous national and international reports. Country figures are rounded to the nearest 10 tU.

[1] Includes Argentina, Belgium, Brazil, Federal Republic of Germany, India, Israel, Japan, Portugal, Spain and Yugoslavia (1984). [2] Totals are of the listed figures only.

TABLE 8. CANADIAN URANIUM UNDER EXPORT CONTRACTS[1]

Country of Buyer	Tonnes U
Belgium	3 325
Finland	3 512
France	9 620
Italy	1 115
Japan	25 046
South Korea	6 841
Spain	3 559
Sweden	8 477
Switzerland	154
United Kingdom	8 293
United States	45 188
West Germany	14 264
Total	129 394

[1] The quantity of uranium specified in all contracts reviewed and accepted under Canadian uranium export policy since September 5, 1974. Country totals are adjusted to reflect new and amended contracts as of December 31, 1987.

TABLE 9. CANADIAN URANIUM EXPORT PRICE[1], 1974-87

	Average Export Prices		Spot Sale
Year	Current Dollars	Constant 1987 Dollars	Portion of Deliveries
	($/kgU)		(%)
1974	39	93	nr
1975	52	112	nr
1976	104	207	nr
1977	110	206	nr
1978	125	221	nr
1979	130	209	nr
1980	135	196	nr
1981	110	144	1.0
1982	113	136	1.5
1983	98	113	10
1984	90	100	26
1985	91	98	20
1986	89	93	21
1987	79	79	35

[1] EMR's Uranium Resource Appraisal Group (URAG) derives the Export Price figure annually. It is based on the average price under all export contracts made by Canadian producers for deliveries in the given year; prices are rounded.
nr Not reported.

TABLE 10. EXPORTS OF URANIUM OF CANADIAN ORIGIN, 1982-86

Country of Final Destination	1982	1983	1984	1985	1986
			(tonnes of contained uranium[1])		
Belgium	85	-	121	157	63
Finland	96	179	137	64	116
France	-	435	525	661	1 399
Italy	143	-	50	53	301
Japan	718	663	2 436	1 799	816
Netherlands	-	-	-	-	42
South Korea	74	94	30	194	403
Spain	110	-	-	-	150
Sweden	889	613	254	514	449
Turkey	-	-	-	-	2
United Kingdom	379	675	692	691	700
United States	4 852[2]	860	2 397	3 892	4 001
West Germany	471	490	295	269	654
Total	7 817	4 009	6 937	8 294	9 096

Source: Atomic Energy Control Board.
[1] Some of this uranium was first exported to intermediate countries, e.g., France, United States and U.S.S.R. for enrichment and then forwarded to the country of final destination.
[2] The bulk of this is uranium exchanged by Eldorado Resources Limited in the purchase of the Rabbit Lake operation.
- Nil.

TABLE 11. VALUE OF EXPORTS[1] OF RADIOACTIVE ORES AND CONCENTRATES[2] FROM CANADA, 1982-86

Country of Initial Destination	1982	1983	1984	1985	1986
			($000)		
United States[3]	346 891	25 400	295 686	98 086	127 418
United Kingdom	11 690	37 175	28 188	113 753	19 893
Japan	-	-	3 475	15 514	-
West Germany	-	-	6 149	1 823	-
France	-	-	36	4 418	19 054
South Korea	-	-	-	-	461
Other	-	-	169	-	-
Total	358 581	62 575	333 703	233 594	166 826

Source: Statistics Canada.
[1] Material clearing customs with destinations as indicated. [2] Primarily uranium in concentrates, i.e., yellowcake. [3] A mixture of sales to the United States and others, primarily in western Europe and Japan, following conversion and enrichment in the United States.
- Nil.

TABLE 12. VALUE OF EXPORTS[1] OF RADIOACTIVE ELEMENTS[2] AND ISOTOPES FROM CANADA, 1982-86

Country of Initial Destination	1982	1983	1984	1985	1986
			($000)		
United States[3]	299 246	261 168	416 670	434 183	437 709
France	36 213	39 037	28 988	77 492	144 629
United Kingdom	796	2 303	1 601	22 174	6 056
Japan	19 617	12 371	35 729	35 892	6 624
West Germany	37 250	32 208	14 364	3 892	29 561
Italy	325	193	526	4 908	13 324
U.S.S.R.[4]	34 854	8 148	-	-	-
Netherlands	45	1 517	598	702	18 136
Finland	199	11	20 128	5 437	7 095
Argentina	214	315	520	1 305	1 136
South Korea	123	3 057	8 311	150	310
Other	5 151	7 287	13 256	4 943	10 024
Total	434 033	367 615	540 700	591 078	674 604

Source: Statistics Canada.

[1] Material clearing customs with destinations as indicated. [2] Includes uranium hexafluoride (UF_6) and radioisotopes for medical and industrial purposes. [3] UF_6 component includes sales to the United States as well as material destined for transshipment, primarily to western Europe and Japan, following enrichment. [4] UF_6 component destined entirely for transshipment to western Europe, following enrichment.

TABLE 13. NUCLEAR POWER PLANTS IN CANADA[1]

Reactors	Owner	Net Capacity (MWe)	In-service Dates
Pickering 1 to 4	Ontario Hydro	2 060	1971-73
Bruce 1 to 4	Ontario Hydro	3 066[r]	1977-79
Point Lepreau	New Brunswick Electric Power Commission, The	635	1983
Gentilly 2	Hydro-Quebec	638	1983
Pickering 5 to 8	Ontario Hydro	2 064	1983-86
Bruce 6 to 8	Ontario Hydro	3 346[r]	1984-87
Darlington 1 to 4	Ontario Hydro	3 524	1988-92[e]
Total net capacity expected by 1993		15 333	

[1] As of July 1987.
[r] Revised; [e] Expected.

FIGURE 1

URANIUM DEPOSITS in CANADA

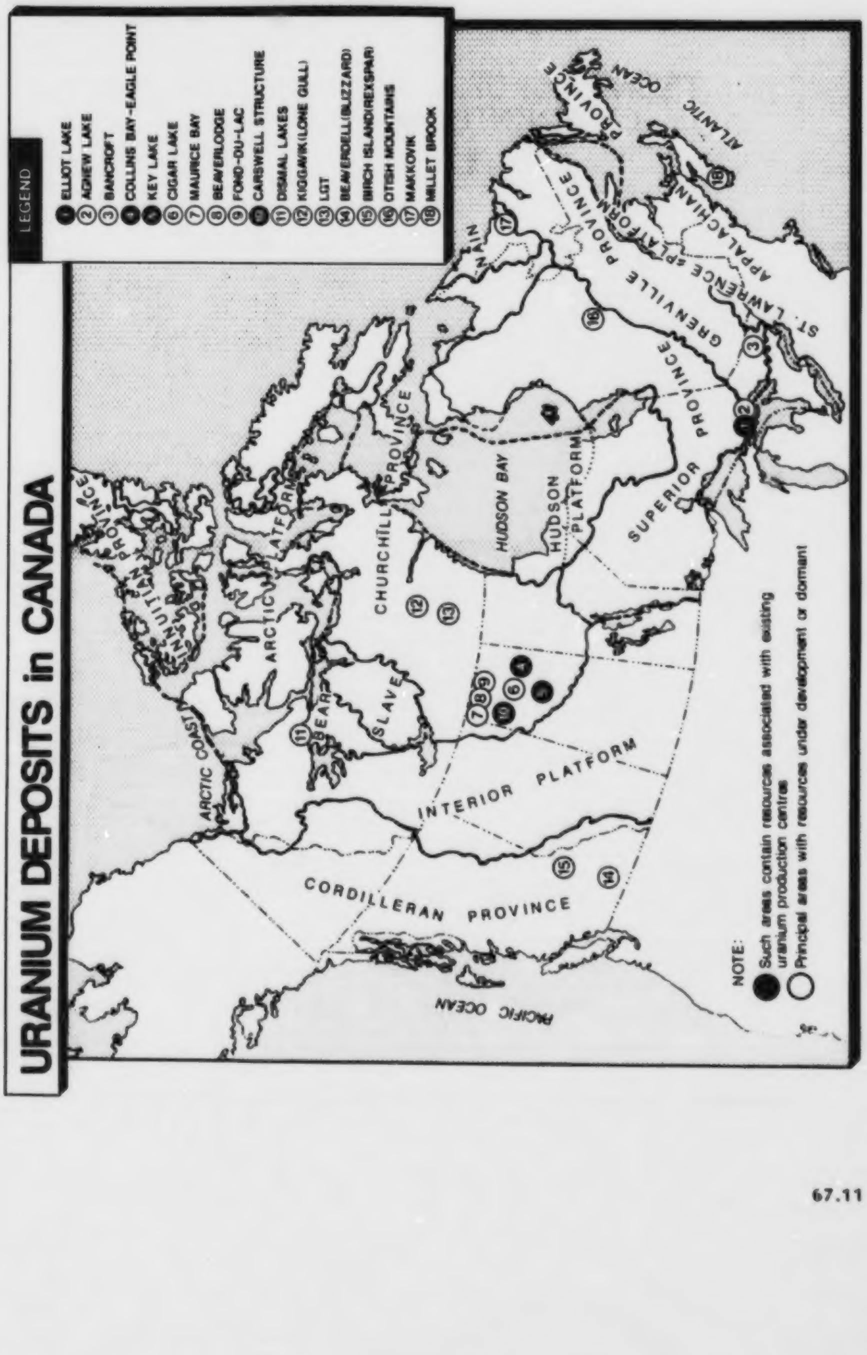
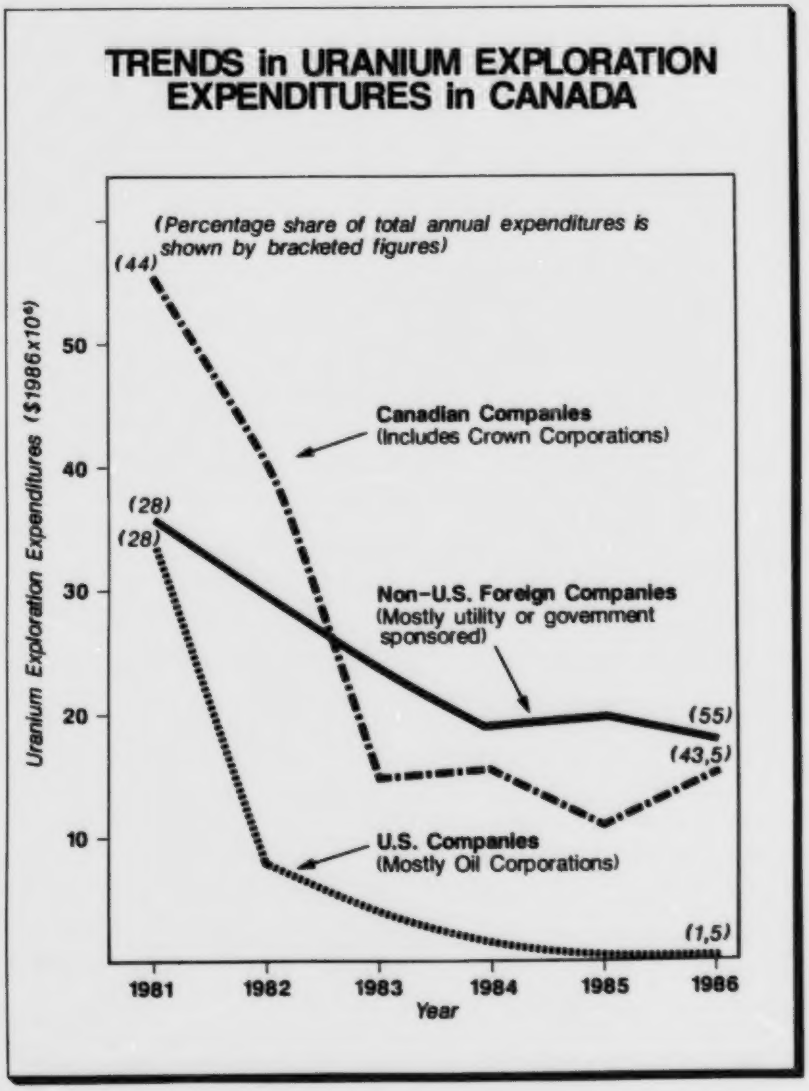

LEGEND
1 ELLIOT LAKE
2 AGNEW LAKE
3 BANCROFT
4 COLLINS BAY-EAGLE POINT
5 KEY LAKE
6 CIGAR LAKE
7 MAURICE BAY
8 BEAVERLODGE
9 FOND-DU-LAC
10 CARSWELL STRUCTURE
11 DISMAL LAKES
12 KIGGAVIK(LONE GULL)
13 LGT
14 BEAVERDELL(BLIZZARD)
15 BIRCH ISLAND(REXSPAR)
16 OTISH MOUNTAINS
17 MAKKOVIK
18 MILLET BROOK
INUITIAN PROVINCE
ARCTIC PLATFORM
ARCTIC COAST
BEAR
SLAVE
CHURCHILL PROVINCE
HUDSON BAY
HUDSON PLATFORM
SUPERIOR PROVINCE
GRENVILLE PROVINCE
ST. LAWRENCE PLATFORM
APPALACHIAN PROVINCE
NAIN PROVINCE
ATLANTIC OCEAN
INTERIOR PLATFORM
CORDILLERAN PROVINCE
PACIFIC OCEAN
NOTE:
● Such areas contain resources associated with existing uranium production centres
○ Principal areas with resources under development or dormant

FIGURE 2



TRENDS in URANIUM EXPLORATION EXPENDITURES in CANADA

FIGURE 3

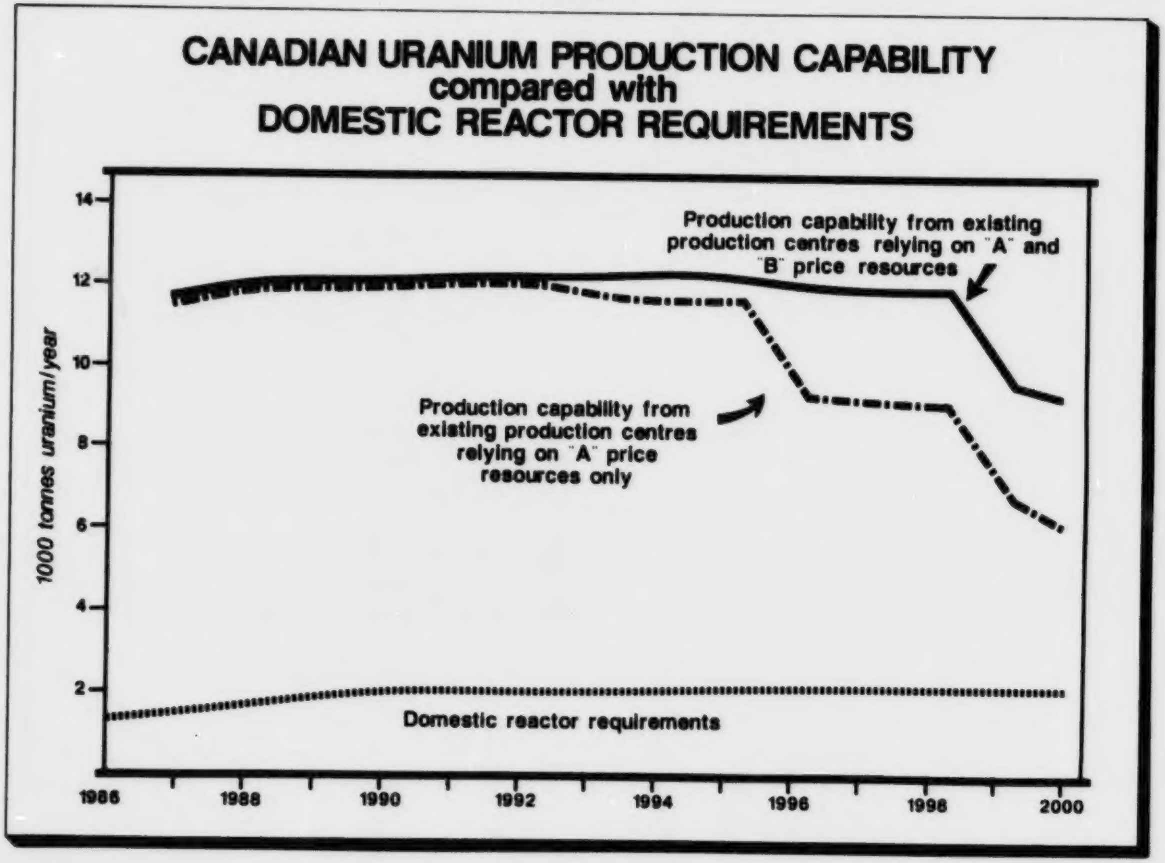
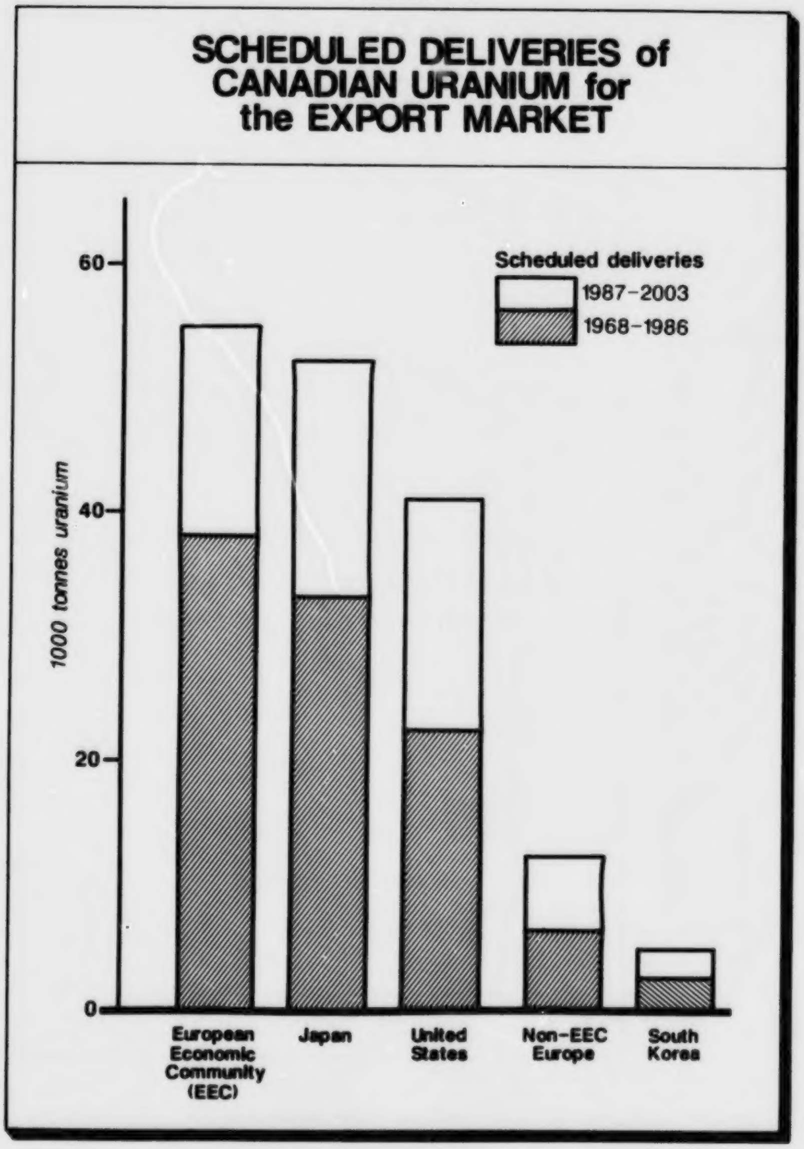

CANADIAN URANIUM PRODUCTION CAPABILITY
compared with
DOMESTIC REACTOR REQUIREMENTS
1000 tonnes uranium/year
14
12
10
8
6
4
2
1986
1988
1990
1992
1994
1996
1998
2000
Production capability from existing production centres relying on "A" and "B" price resources
Production capability from existing production centres relying on "A" price resources only
Domestic reactor requirements

FIGURE 4



SCHEDULED DELIVERIES of CANADIAN URANIUM for the EXPORT MARKET

Vanadium

D. KING

Vanadium is derived from natural ores and from vanadium-containing residues such as by-products from crude oil refining. The basic feedstock used to obtain all other vanadium products is vanadium pentoxide (V_2O_5), which is not currently produced in Canada. One domestic company, Masterloy Products Limited, produces ferrovanadium from imported vanadium pentoxide. Canada consumed about 590 t of ferrovanadium in 1986.

Following the low point in demand in 1983, at the end of the recent economic recession, the world vanadium industry rebounded strongly in 1984 and has since continued a moderate recovery through 1987. Supply lost through the termination of output in Finland in 1985 was made up by increased output from South Africa. However, the possibility of more civil unrest in South Africa introduces some uncertainty for future supply from this predominant source. Prices firmed in 1986 and 1987 because of the improved demand from steel and titanium producers, coupled with the loss of Finnish output.

The United States, which had virtually lost its output of by-product vanadium from uranium mills and vanadiferous clays, recovered part of the lost capacity by expansion of its capacity to recover vanadium from petroleum-residues and spent catalysts. In China, greater consumption of vanadium in steel resulted in less vanadium for export.

An embargo by the United States, Japan and western European countries against South African steel imports was initiated in the last quarter of 1986. However South Africa was still able to export a certain amount of its steel to Asian and other countries and the reduction in co-product vanadium slag output was only 10%. The embargo, losses of Chinese exports and termination of Finnish production combined to increase the dependence in many western countries on South African vanadium.

In 1985, the United States government purchased vanadium materials for the National Defence Stockpile for the first time in 23 years. In mid-1986, a U.S. Bureau of Mines (USBM) report on the availability of critical materials from South Africa indicated that private stockpiles contained 21 months of U.S. consumption, based on the 1984 rate. The report concluded that this would reduce the impact of a reduction in South Africa supplies over the near term and that substitution and conservation could reduce demand by 10-25%, also over the short term.

Non-communist world demand in 1987, which slipped about 8% from its high in 1986, was expected to remain firm during 1988 in line with projected steel and titanium consumption.

CANADIAN DEVELOPMENTS

Vanadium occurrences are widespread throughout Canada. The most common type of occurrence is vanadium contained in titaniferous magnetites. While the grade of the best deposits, at 0.6% vanadium pentoxide (V_2O_5), is comparable to the grade of some deposits now being worked in other countries, it is only about one-third the grade of titaniferous magnetites being mined for vanadium in the Republic of South Africa. However, milling tests on material from the large titaniferous magnetite deposit at Lac Doré in Quebec yielded a magnetic concentrate containing about 1.4% V_2O_5, which is almost comparable with ore grades at Highveld Steel and Vanadium Corporation Limited in South Africa. The non-magnetic fraction offers some potential as a titanium concentrate although recoveries would be low. Due to its large size, the deposit could support a scale of output of vanadium that would be limited only by market demand.

Uranium ores in Canada are too lean in vanadium to warrant economic recovery. There are a few known occurrences in Canada of vanadium minerals dispersed in beds of sandstone, limestone or shale. These contain less than 0.3% V_2O_5.

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The bitumen in the Alberta tar sands contains only 0.02 to 0.05% V_2O_5. However, vanadium becomes concentrated to 4 to 5% V_2O_5 in the fly ash generated when some of the bitumen throughput is burnt during processing. The Oil Sands Group division of Suncor Inc.'s operation produces an estimated 33 000 t/y of carbon-free fly ash containing about 1 500 t/y V_2O_5. In a somewhat different process employed by Syncrude Canada Ltd. (Syncrude), the grade of its approximately 50 000 t/y fly ash is only about 0.8% V_2O_5. After additional carbon removal, the residual 7 200 t/y of ash would contain about 5.4% V_2O_5 for a potential recovery of less than 400 t/y of V_2O_5. Much of the vanadium entering Syncrude's process reports some 1 300 t/y of spent catalyst, which contains about 20% V_2O_5 or 260 t/y.

Carbovan Inc., a joint venture of Agra Industries Limited and Renzy Mines Ltd. has developed and piloted a process to extract vanadium pentoxide from fly ash. Engineering was under way to update a previous pre-engineering study, and construction of a demonstration plant could begin before mid-1988. The plant is intended to treat the fly ash generated by Suncor Inc. and would be located nearby. Planned design capacity of the \$10 M plant is about 1 150 t/y of V_2O_5.

The production of by-product vanadium from tar sand would be limited by the scale of bitumen production and by the type of bitumen extraction process. However, the availability of infrastructure, labour and energy in the vicinity of the tar sand operations would be a positive factor in developing this source of vanadium.

Increases in bitumen production, such as those announced over the past year, will not necessarily lead to an increase in fly ash because of a limit on oil burning imposed by environmental regulations. However, should lime or magnesium injection be implemented to curb sulphur emissions, more fly ash could be generated and higher concentrations of vanadium in the ash might be achieved.

Because there is presently no Canadian producer of vanadium feedstock, Masterloy Products Limited (Masterloy) imports all of its vanadium pentoxide for the production of ferrovanadium. Its Ottawa plant has a capacity of approximately 1 400 t/y ferrovanadium. About 78% of the imported raw materials come from South Africa. Additional V_2O_5 has been imported from the United States since the loss of Finnish supplies.

Masterloy supplies the major share of the Canadian demand for ferrovanadium in competition with imports, mainly from the United States. Approximately one fifth to one third of its output of ferrovanadium is exported to the United States.

The principal consumers of ferrovanadium in Canada are: Stelco Inc.; The Algoma Steel Corporation, Limited; Dofasco Inc.; IPSCO Inc.; Atlas Steels division of Rio Algom Limited; and Sydney Steel Corporation.

WORLD DEVELOPMENTS

United States

The major restructuring of the U.S. vanadium industry, caused by the sharp decline in steel consumption during 1982-84, and coupled with persistently low coproduct uranium prices, resulted in a shrinkage of primary capacity. This lost capacity has since been partially rebuilt through the increasing extraction from slags, petroleum residues, fly ashes and spent catalysts. The purchase of the tungsten and vanadium assets of Umetco Minerals Corporation (a subsidiary of Union Carbide Corporation) by Strategic Minerals Corp. (Stratcor) was completed in 1986. Stratcor installed new solvent extraction equipment at its Hot Springs, Arkansas mill, which was previously designed to treat vanadiferous clays. The mill now has a production capacity of 2 300 t/y and extracts vanadium from a wide range of waste materials, including petroleum residues, at a low operating cost. Some of the product is treated at Stratcor's own ferrovanadium plant in Niagara Falls, New York. Stratcor has modified this plant to produce Nitrovan and it also produces vanadium-aluminum. Spent catalysts containing vanadium are treated by the Gulf Chemical Corp. at Freeport, Texas and by AMAX Nickel Inc. at Braithwaite, Louisianna. The Freeport extraction process begins by roasting the spent catalyst with sodium carbonate and leaching with water, followed by selective precipitation of vanadium and molybdenum. AMAX Inc. and CRI Ventures Inc., in a joint venture called CRI-MET, utilises a caustic soda pressure leach to solubilise vanadium and molybdenum, followed by selective precipitation. Further treatment also recovers pure alumina, cobalt and nickel. The Long Island Lighting Company (LILCO) produces fly ash containing up to 39% V_2O_5 by injecting magnesium oxide into its oil-burning fire boxes, using oil containing 50-200 ppm vanadium, at power stations in Northport and Port Jefferson, New York. Foote Mineral Company, a producer of ferrovanadium in Exton, Pennsylvania was purchased by Shieldalloy Corporation, which is owned by Metallurg Inc.

South Africa

The output of Highveld Steel of South Africa, the largest South African vanadium producer, rose from 14 300 t in 1985 to 17 000 t in 1986, when its new No. 2 plant began to run at full capacity and added 30% to output. Vansa Vanadium S.A. Ltd. expected that its new mining property at Kennedy's Vale would start production in 1988. The 2 700 t/y V_2O_5 recovery plant is being located at Steelpoort. The Vametco Minerals Corp. vanadium slag plant, which was built in 1984 at Brits and which is now owned by Stratcor as a result of its purchase of Umetco assets, began operating in 1986. The plant also produces Nitrovan.

China

China intends to double its steel production at Panzihua to 3 Mt/y and slag containing 25% V_2O_5 will be treated at the Jinzhou and Emei plants. Construction began in 1985 and is due for completion in 1995. China's total V_2O_5 production in 1986 was an estimated 9 000 t.

Brazil

Rautaruukki Oy, having terminated its own production in Finland, negotiated the sale of its processing technology to the Odebrecht Mining Co. of Brazil. Odebrecht's 4 500 t/y refinery is to be built at Maracas, Bahia State. The US$40 M plant will use ore averaging 1.3% V_2O_5 from Maracas. Brazil's annual ferrovanadium capacity was about 1 000 t in 1986.

MINERALS, PRODUCTS, AND PROCESSES

Vanadium is found in most parts of the world, but rarely occurs as the sole component of economic interest. The principal economic minerals are:

Carnotite - $K_2O.2U_2O_3.V_2O_5.3H_2O$
Roscoelite -
  $2K_2O.2Al_2O_3(Mg,Fe)0.3V_2O_5.10SiO_2.4H_2O$
Descloizite - $4(Cu,Pb,Zn)O.V_2O_5.H_2O$
Titaniferous Magnetite -
  $FeO.TiO_2.FeO(Fe,V)O_3$ and V_2O_5 in solid solution
Phosphate Rock - $Ca_5(PO_4)_3$ (F,Cl,OH) with VO_4 replacing some PO_4 ions.

The extraction of vanadium from mineral sources invariably requires hydrometallurgical processing but some raw materials are given a prior pyrometallurgical treatment to yield an intermediate product amenable to leaching. Titaniferous magnetite is the predominant mineral. It accounts for essentially all of South African and Soviet production and is generally smelted to produce iron and a vanadium rich slag. The slag can then be leached to extract vanadium, which is normally recovered as vanadium pentoxide.

The phosphate ores of Idaho are also pre-treated pyrometallurgically. In this case, the intermediate product is vanadium-bearing ferrophosphorus, which is then leached.

Other intermediate products are produced incidentally during the processing and burning of petroleum. These include vanadium-bearing fly ash, boiler residues, refinery residues and coke. The vanadium from these are then recovered by a process incorporating hydrometallurgy.

Direct hydrometallurgical treatment is applied to some ores, including the vanadiferous clays of Arkansas and to the fine fractions of titaniferous magnetite at Highveld that are directly treated at its Vantra plant. In previous years, lead-vanadate ores at Kabwe, Zambia were acid leached. The uranium-vanadium carnotite ores of Colorado were also directly leached with acid.

In the Highveld operation, titaniferous magnetite containing 1.5 to 1.8% V_2O_5 from the open cast mine at Mapochs is pre-reduced in kilns and then smelted electrically to produce slag containing about 25% V_2O_5 and steel. Most of the slag is exported and treated elsewhere. At Highveld's Vantra division, titaniferous magnetite fines are partially concentrated by magnetic separation and then mixed and roasted with sodium sulphate and/or sodium carbonate. The resulting sodium vanadate is leached with water. A precipitate of ammonium metavanadate (AMV) is obtained by adding an excess of ammonium chloride to the sodium vanadate solution. The AMV is heated to remove the ammonia, leaving vanadium pentoxide, which is melted and solidified into flakes of oxide. Ammonia from the AMV and from evaporation of the barren solution is recycled.

Commercially pure vanadium pentoxide forms the basic raw material for much of the production of ferrovanadium and other alloying agents. A reduction of the oxides of vanadium and iron by aluminum powder enables the production of ferrovanadium containing 80% vanadium and low carbon. Hydrocarbon or carbon reduction of vanadium pentoxide is used to produce the proprietary alloys Carvan, ferrovanadium carbide and Nitrovan, which each contain about 10% carbon and 70 - 86% vanadium, depending on the particular product. Ferrosilicon is used as a reductant in the production of Ferovan, which contains about 42% vanadium, 7% silicon and 4.5% manganese. Vanadiferous slag can be reduced directly to produce ferrovanadium containing 25 - 50% vanadium.

In 1984, Umetco announced the availability of an additional product called Vanox, which is essentially vanadium trioxide that is produced by partial reduction of vanadium pentoxide. This product can be added directly to an argon oxidation decarburization (AOD) steelmaking vessel. Its high melting point enables it to become dispersed in the steel melt where the particles become reduced within two minutes.

Vanadium-aluminum master alloys are produced by aluminothermic reduction of vanadium pentoxide, and are used in the production of nonferrous alloys, particularly titanium alloys for aerospace applications.

USES

The steel industry, which uses vanadium as an alloying agent in various grades of steel, accounts for about 85% of total consumption. Vanadium is also an essential alloying element in titanium alloys and it is a major component of catalysts that are used in sulphuric acid production. Nonferrous metal alloys consume about 9%, chemical catalysts and ceramics about 3% and cast irons 1%.

Additions to steel are made in the form of ferrovanadium or one of the proprietary alloys containing iron and vanadium. Improvements to the strength, hardness and wear resistance of steels are due to vanadium's chemical and crystallographic behaviour, which produces several effects. Vanadium forms carbides and nitrides within the iron matrix, which limit grain growth, and the resulting grain refinement increases the toughness and strength of the steel. Vanadium also stabilizes the ferrite phase and suppresses the formation of bainite and pearlite structures within the steel, thereby improving hardenability and weldability.

The most widespread usage of vanadium occurs in high-strength-low-alloy (HSLA) steels and full alloy steels, accounting for about 35% and 25%, respectively, of the total vanadium used in ferrous alloys. HSLA steels have replaced carbon steels in many instances where the higher intrinsic strength of the steel permits a lower design weight, which can offset the somewhat higher per-unit-weight cost. The lighter weight also results in savings in transportation costs, and further cost savings are obtained through improved weldability. The major uses of HSLA steels are in pipelines, concrete reinforcing bars, structural shapes and automobile components.

Vanadium is used in HSLA steels in combination with other alloying elements, including niobium and molybdenum. The ratios of these elements can be varied to some degree without adverse effects and this is sometimes done to accommodate price changes or the availability of the respective elements. The percentage contents of niobium and vanadium are low, ranging between 0.03% and 0.08%, and these two metals are largely interchangeable. Molybdenum can vary between 0.15 and 0.3%, chromium 0.15 to 0.25% and nickel nil to 0.35%. Vanadium is essential in Arctic pipelines where it imparts toughness at cold temperatures, making the steel less prone to cold embrittlement. Large quantities of vanadium-bearing HSLA steels have been manufactured and used in the United States, West Germany and the United Kingdom for petroleum products and natural gas pipelines.

In recent years, yield-strength requirements for concrete reinforcing bars have risen and this trend is expected to continue in the future. While these higher yield strengths can be achieved with the addition of more carbon and manganese, the two traditional steelmaking additives, the resulting loss in weldability limits this practice. HSLA steels are finding increased application in structures such as bridges, elevated roadways, and in transportation equipment such as rail cars and automobiles.

The earliest use of vanadium in steel was as an addition to tool steels, used for high-speed machining. Vanadium inhibits grain growth and enables the steels to maintain their hardness and, therefore, their cutting edge at the high temperatures generated in the tool tip during high-speed machining. This remains an important application for the metal. Vanadium at concentrations of 1 - 5% is used in both the high-tungsten tool steels that were first developed and in the later generation of molybdenum-tungsten tool steels.

Vanadium is also used in making high-temperature steels such as those employed in steam power plants for steam pipes and headers. Other areas where vanadium is used in the iron and steel industry include: heavy iron and steel castings; forged parts, such as crankshafts; automobile parts, such as gears and axles; springs, ball bearings, hammers and dies. Vanadium is also used in iron-base superalloys employed in jet engines and turbine blades where high-temperature strength is essential.

The most commonly used titanium alloy, for applications that utilize titanium's high strength, is an alpha beta alloy containing 90% titanium, 6% aluminum and 4% vanadium. Beta grade alloys contain 7.5 to 8.5% vanadium. Commercially pure titanium, used primarily in industrial applications requiring high corrosion resistance, but not necessarily high strength, contains no vanadium. Aerospace presently provides the major market for fabricated, forged and cast titanium alloys and there is essentially no substitute for vanadium as a strengthening element in these alloys.

Vanadium is added to copper-base alloys to control gas content and refine the microstructure, and a small amount is added to aluminum alloys for internal combustion engine pistons to improve high-temperature operating properties.

A potential use for high-vanadium alloys is as a cladding material in fast-breeder nuclear reactors. Vanadium has a low neutron capture cross-section (i.e., permits relatively free movement of neutrons within the reactor core), good resistance to corrosion by liquid sodium (the reactor coolant), and good high-temperature operating properties.

Vanadium is used in making vanadium carbide, employed as coatings in the manufacture of both hand and machine tools, and in the production of various chemical salts. Compounds of vanadium are used in the chemical industry in oxidation catalysts for the production of sulphuric acids and the cracking of petroleum products. Other uses in the chemical industry include pigments in glass and ceramics, driers in paints and varnishes, and in the processing of colour film.

PRICES

The Metals Week prices for V_2O_5 have remained unchanged since 1985 at $3.35-3.65/lb. Ferrovanadium and Ferovan list prices in December 1986 were $6.50 and $6.30/lb. V, respectively, close to those of 1984. Ferrovanadium, containing 80% V, increased to $6.60-6.75/lb. V and Ferovan to $6.60/lb. V by the end of 1987. In the fourth quarter of 1987, U.S. ferrovanadium transaction prices rose from $6.15-6.30/lb. to $6.30-6.50/lb. These increases conformed with those for vanadium pentoxide feedstock, which rose from $2.41 to $2.65/lb. V_2O_5 in 1986 and from $2.65 to $2.95 in the fourth quarter of 1987.

Stratcor raised its price in 1987 for ferrovanadium to $6.75/lb. V, f.o.b. Niagara Falls. Its Vanox was quoted at $5.75/lb. V and its Nitrovan, containing 5-10% nitrogen, at $7.00/lb. V.

Factors enabling the price increases of feedstock by the predominant supplier, Highveld, were the permanent closure of Finnish production, representing a production loss of 9 500 t/y V_2O_5, the generally firm demand and lower shipments from China.

OUTLOOK

The steel and titanium alloy industries, the main consumers of vanadium, have been relatively firm since 1984. Also, there has been a gradual increase in the demand for high-strength-low-alloy (HSLA) steels, which are significant users of vanadium.

Titanium alloys have been considered a faster long-term growth market than HSLA steels. However, despite strong aircraft sales, recent titanium demand for this market has not been vigorous, mainly because technological improvements have reduced the ratio of titanium purchased, to titanium remaining in finished aircraft parts.

The outlook for vanadium demand in 1988 is very much dependent on what happens to the overall economy. On balance, a reduction in world consumption of about 10% is quite likely.

Since 1986, vanadium consumers have become even more dependent on South African supplies of feedstocks. Some lowering of this dependence could occur in the medium-term because the United States is strengthening its capacity to produce vanadium from waste materials and other countries such as China, Canada and Brazil are implementing plans for new production. Nevertheless, South Africa, with its large capital installations already in place and with a long record of successful production, technology and marketing, will probably remain the predominant supplier for at least the next 5 to 10 years.

Canadian and United States interests have both expressed reservations about the Canada-U.S. Free Trade Agreement. Canada's sole ferrovanadium producer could face competition from larger, more versatile, and lower cost plants in the United States. On the other hand, United States primary producers are concerned about the removal of the 16% import duty on V_2O_5 concentrates because of the risk that off-shore supplies might be transshipped through Canada.

The long-term growth of vanadium demand is estimated to be about 2%/y in the United States and about 3%/y in the rest of the non-communist world.

Supply could be adversely affected by civil unrest in South Africa and by its political relations with other countries, although it has been reported that the government there would not willingly curtail exports because of its need for export earnings.

PRICES

United States vanadium prices published in "Metals Week".

	December 1984	December 1985	December 1986	December 1987
	(US$)			
Vanadium pentoxide, per pound of V_2O_5, f.o.b. mine or mill				
Chemical	4.10 - 4.94	4.10 - 4.94	4.10 - 4.94	4.10 - 4.94
Metallurgical	3.35 - 3.65	3.35 - 3.65	3.35 - 3.65	3.35 - 3.65
Ferrovanadium, per pound of V packed, f.o.b. shipping point				
U.S. producer, 80% V	6.50	5.00	6.50	6.00 - 6.75
Carvan	6.00	5.00	..	..
Ferovan	6.25	5.00	6.30	6.60

f.o.b. Free on board; .. Not available.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
CANADA					
32900-1	Vanadium ores and concentrates	free	free	free	free
35101-1	Vanadium metal, not including alloys	free	4.0	25	free
37506-1	Ferrovanadium	free	4.0	5	free
37520-1	Vanadium oxide	free	free	5	free
UNITED STATES (MFN)					
422.58	Vanadium carbide		4.2		
422.60	Vanadium pentoxide (anhydride)		16		
422.62	Other vanadium compounds		16		
427.22	Vanadium salts		7.5		
601.60	Vanadium ores		free		
606.50	Ferrovanadium		4.2		
632.58	Vanadium metal, unwrought, waste and scrap		3.7		
632.68	Vanadium alloys, unwrought		3.0		
633.00	Vanadium metal, wrought		5.5		

Sources: Customs Tariff 1987, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1987), USITC Publication 1910; U.S. Federal Register, Vol. 44, No. 241.

TABLE 1. CANADA, VANADIUM IMPORTS AND EXPORTS, 1984-87

	1984	1985	1986	1987[1]
		(tonnes)		
Imports				
Vanadium oxides				
United Kingdom	6	-	-	-
Belgium-Luxembourg	302	-	41	-
Finland	360	504	126	36
West Germany	3	-	1	-
South Africa	1 231	569	913	819
United States	9	2	46	124
Brazil	-	6	2	-
China, People's Republic	-	48	48	66
Other	-	-	-	5
Total	1 911	1 129	1 177	1 050
Ferrovanadium				
Austria	17	17	34	0
West Germany	-	-	-	5
United Kingdom	-	-	18	0
United States	228	171	111	123
Total	245	188	163	128
Exports				
Ferrovanadium (at 81% V content)				
United States	516	189	241	..

Sources: Statistics Canada; U.S. Bureau of Mines Import Statistics.

[1] January-September.

- Nil; .. Not available.

TABLE 2. CANADA, VANADIUM CONSUMPTION, 1984-86

	1984	1985	1986
		(tonnes)	
Ferrovanadium			
Gross weight	754	656	586
Vanadium content	589	522	433

TABLE 3. MARKET ECONOMIES, VANADIUM CONSUMPTION, 1982-87

Year	Tonnes
1982	38 900
1983	29 200
1984	34 000
1985	34 400
1986	38 500
1987e	35 400

Source: U.S. Bureau of Mines.

e Estimate.

TABLE 4. WORLD, VANADIUM OXIDE PRODUCTION CAPACITY, 1983, 1984 AND 1990

	1983	1984	1990^e
		(tonnes contained V)	
Primary capacity[1] (from ores, concentrates and slags)			
United States	9 000	9 000	10 300
Chile	1 100	1 100	1 100
Finland	3 800	3 800	-
South Africa (RSA)	17 200	17 200	27 000
Australia	900	900	3 000
New Zealand	-	-	2 300
China, People's Republic (PRC)	6 000	6 500	8 000
U.S.S.R.	18 000	21 000	28 000
Total	57 500	61 000	81 200
Secondary capacity[2] (from petroleum ash, residues, spent catalysts)			
United States	6 400	6 800	10 000
Canada	-	-	1 500
Japan	1 100	1 100	1 500
Total	7 500	7 900	13 000

Source: U.S. Bureau of Mines Mineral Facts and Problems No. 675, 1985 edition.

[1] Production credited to country of origin of vanadiferous material. [2] Production credited to country where vanadium is extracted.

^{e} Estimated; - Nil.

TABLE 5. ESTIMATED WORLD PRODUCTION OF V_2O_5 EQUIVALENT, 1982-87

	1982	1983	1984	1985	1986	1987
			(tonnes)			
South Africa	22 070	16 640	23 500	26 400	29 400	..
United States	9 590	5 240	3 320	4 600[1]	5 900[1]	..
Finland	5 930	6 000	5 770	4 020	0	..
Japan	1 290	1 330	1 310	1 440	1 430	..
China, People's Republic	8 500	8 500	8 500	8 500	8 500	..
Total	47 380	37 710	42 400	44 960	45 230	38 000^e

Source: U.S. Bureau of Mines Minerals Yearbook 1986.

[1] Includes only V_2O_5 from petroleum residues, ashes, and spent catalysts.

^{e} Estimate; .. Not available.

Zinc

A. BOURASSA

Western world zinc consumption increased for the fifth consecutive year in 1987 to over 5 Mt. Increases also occurred in mine and metal production. Prices averaged slightly higher in 1987 but zinc was the only major nonferrous metal that did not register major price increases in 1987. Zinc metal stocks have declined almost steadily from their peak in 1977, falling by more than 50% over the decade and now standing at about 550 000 t, or 5 to 6 weeks of consumption. The outlook for 1988 is for slight increases in consumption and metal production, and stable prices hovering around the US$0.38 level on the London Metal Exchange.

CANADIAN DEVELOPMENTS

Mine output in Canada increased markedly in 1987 to about 1 490 000 t. A less significant increase also occurred in refined metal production which reached 610 000 t. However, metal production was well below capacity in both 1986 and 1987 because of lengthy labour disputes at the two largest facilities. Canadian metal consumption also increased in 1987 to an estimated 156 000 t.

The single most important factor behind the increase in mine output was the accelerated production schedule at the Pine Point mine in the Northwest Territories prior to its closing around mid-year. Some of the ore produced has been stockpiled and milling will continue until the spring of 1988. Shipments from the concentrate stockpile will continue until 1990. During that year, the Cominco Ltd.'s Trail zinc complex should receive its first shipments of concentrate from the company's Red Dog mine in Alaska.

Zinc capacity at the large Faro mine of Curragh Resources Corporation in the Yukon was increased by 45 000 t of zinc to 180 000 t/y. Giant Resources Limited of Australia purchased a 46% interest in the Faro mine and Curragh Resources Corporation now holds a similar 46% share while Boliden AB owns the remaining 8%. Development work has started on the nearby Grum and Vangorda deposits. Production from these deposits will be gradually phased in as production from Faro declines.

In September, Newfoundland Zinc Mines Limited reopened its Daniel's Harbour zinc mine that had been closed in June 1986. The mine will produce 40 000 t/y of zinc. A $2 million loan from the province assisted in reopening the mine. Audrey Resources Inc. opened the new Mobrun mine in July. The mine will produce about 6 000 t/y of zinc and is near Rouyn, Quebec.

Hudson Bay Mining and Smelting Co., Limited (HBM&S) closed two small mines this year in Manitoba, the Great Lake and Centennial mines, with a combined capacity of 5 500 t/y zinc. The company also acquired the Ruttan mine from Sherritt Gordon Mines Limited and will operate it at about 13 000 t/y of zinc. The company is studying the modernization of its zinc smelter using new pressure leaching technology. At year-end, workers agreed to a new three year contract with HBM&S. The Canadian smelting and refining industry could therefore look at a year free of labour disruption in 1988.

The Cominco metallurgical complex at Trail and the Kimberley mine were closed from May to September because of a four month strike. Mitsui Mining & Smelting Co. Ltd. purchased two million Cominco shares, roughly 3% of the issued stock, strengthening the link between the companies. Mitsui will likely purchase a substantial portion of Red Dog's excess production. Following Metallgesellschaft AG's recent major investment in Cominco, the former has set up a Canadian-based holding company, Metall Mining Corporation, that will group most of the company's international mining interests.

The Canada-U.S. Free Trade Agreement should be a positive development for the Canadian zinc industry. Removal of the low U.S. tariffs should improve profitability on U.S. sales. The industry does not however expect to significantly increase sales volume to the U.S. Canadian zinc metal exporters

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already have the largest share of U.S. metal imports. There is also the possibility that sales of Canadian made alloys, powders and flakes to the United States could be facilitated in some geographical areas and product sectors.

The free trade agreement does not end Canadian zinc industry concerns about the U.S. market. In August, the U.S. Lead-Zinc Producers Committee changed its name to the Nonferrous Metal Producers Committee after a major U.S. copper producer agreed to join. The new group intends to pursue its fight against "subsidized Canadian companies in a free trade area".

The Canadian zinc mining industry is generally considered to be very cost competitive internationally. Most zinc mines contain substantial amounts of marketable lead and silver, and in some cases, copper and gold. The polymetallic nature of these deposits reduces the vulnerability of the producers to the price fluctuations of an individual commodity. Additionally, Canadian mines have generally good grades, are large, well equipped and managed, and with the benefit of a productive labour force.

The zinc smelting and refining industry is regarded as one of the most modern and competitive in the world. The only exception is the Hudson Bay Mining and Smelting smelter in Flin Flon. It is old and inefficient but the company is actively considering a modernization project.

WORLD DEVELOPMENTS

Western world zinc mine production increased by about 6% in 1987. Canada accounted for about half the increase but most other major producers also registered increases.

In Australia, Aberfoyle Limited opened its Hellyer mine in 1987. Present capacity is 28 000 t/y of zinc but an expansion to 92 000 t is already under way. Mining has also started at the Cadjebut mine in Western Australia. It is owned by Billiton N.V. (42%) and BHP Minerals Ltd. (58%). The ore is now being stockpiled for processing when the concentrator is completed in early 1988. Mine capacity is 41 000 t/y of zinc. Commercial production at the Hilton mine is now being phased into Mount Isa's existing operations. The Woodlawn mine was acquired by Denehurst Ltd. from CRA Limited. Open pit operations have ceased and production has now gone underground. Capacity is estimated at 40 000 t/y of zinc.

After several delays due to postponements of equipment deliveries, the Morro Agudo mine in Brazil finally opened in December. Capacity is 22 000 t/y of zinc. The mine is owned by Mineracao Morro Agudo S.A. In Honduras, American Pacific Holdings (APH) of Greenwich, Connecticut took over the El Mochito mine from an AMAX Inc. subsidiary, Rosario Resources Corporation. American Pacific is now negotiating special concessions from the government in order to reduce costs and return the mine to profitability.

India will receive $25 million in assistance from the U.K. government to develop the Rampura Agucha mine in Rajasthan. The mine would produce 70 000 t/y of zinc by 1990.

Four mines were closed in Japan in 1987. They are the Akinobe, Shakanai, Hosokura and Nakatatsu mines. Total capacity was about 62 000 t/y of zinc. A new mine, the Nurukawa owned by Uchinotai Mining Co., with a zinc production capacity of 4 000 t/y was opened in 1987.

The Peruvian government authorized the state marketing company Minero Peru Comercial SA (Minpeco) to substitute itself into all contracts between domestic mining and metals companies and foreign buyers. The measure was strongly denounced by industry and will not be enforced immediately. Empresa Minera del Centro del Peru S.A. (Centromin-Peru) completed expansion of the Andaychagua San Cristobal mine. Additional zinc capacity is estimated at 15 000 t/y.

In Spain, Boliden AB bought Andaluza de Piritas S.A.'s (APIRSA) Aznacollar lead-zinc-copper mine. No change in capacity is planned at this mine. In Sweden, Boliden has decided to extend the life of the Stekkenjokk mine by a year to November 1988. Boliden also announced a plan to invest up to US$480 million on a domestic mine expansion program. The objective is to assure a long term and secure source of feed for the Ronnskar copper and lead smelting complex. Boliden now operates 16 mines in Sweden, producing a total of 131 000 t/y of zinc. The program would cover about 20 projects including the expansion of the Laisrall mine which produces about 10 000 t/y of zinc. Boliden has asked the Swedish government to fund up to 35% of the program but the government responded in December by offering $12.8 million. Boliden reacted by stating that drastic measures would have to be taken as a result. Boliden is now wholly-owned by Trelleborg AB.

In the United States, Cominco Alaska Incorporated is going ahead with the development of the Red Dog deposit in Alaska. Construction of the access road has started. Ralph M. Parsons has been awarded the design and procurement contract for the lead and zinc concentrator. The plant will mostly be built outside Alaska and shipped in modules during the 1989 summer. Production should start in 1990 at a rated capacity of 314 000 t/y of zinc. Another new project in Alaska, the Greens Creek mine, is also being developed by Amselco Minerals Inc., part of the BP Minerals International Ltd. group. Production should start in mid-1988 from reserves estimated at 3.2 Mt grading 3.9% lead and 9.7% zinc. Zinc capacity is 30 000 t/y.

Smelting and Refining

Non-socialist world refined zinc production increased by 4% in 1987. Again, most major producers except Japan registered increases. At time of writing it was still too early for a final estimate of Chinese trade in zinc metal. It appears that China, after importing huge tonnages in the first half of the 1980s, was a net metal exporter to the west in the first nine months of 1987. However, purchases made in the final months of the year probably made China a modest net importer.

Industry has recognized for several years that there is excess zinc smelting capacity in Europe. Earlier this year, five European zinc smelting companies, Boliden AB, Outokumpu Oy, Preussag AG, Société minière et métallurgique de Penarroya S.A., and Société des Mines et Fonderies de Zinc de la Vieille-Montagne SA (Vieille-Montagne SA), joined to look into ways of optimizing their smelting capacities and possibly rationalizing the industry by closing one or more smelters. The talks broke down in the fall. Later in the year, Preussag announced that it would close its Harlingerode smelter in 1988. Capacity is 70 000 t/y of zinc.

In Australia, North Broken Hill Holdings Ltd. announced it may expand the Risdon smelter in Tasmania to 320 000 t/y in the early 1990s. The smelter is now being expanded by 6 000 t to 220 000 t/y. The Paraibuna smelter in Brazil is being expanded from 30 000 to 60 000 t/y but it was announced that capacity could possibly be increased later to 120 000 t/y. In Finland, Outokumpu Oy's Kokkola facility has been expanded by 10 000 t to 170 000 t/y. In France, Vieille-Montagne closed the Viviez smelter. However, the lost capacity is compensated by the expansion of the Auby plant which will have a 200 000 t/y capacity. Italy's Nuova Samim inaugurated the first smelter using the U.S.S.R. Kivcet technology in the western world in Porto Vesme, Sardinia. Capacity is 84 000 t/y of zinc.

In India, the Cominco Binani Zinc Limited smelter in Kerala has been expanded by 4 000 t to 20 000 t/y capacity. Part of a $25 million assistance package, mentioned earlier, is for the Chaderya smelter to be in production in 1991 with 70 000 t/y capacity. In Japan, Hosokura Mining Co. Ltd. closed its Miyagi smelter in February. Capacity was 22 000 t/y.

Korea Zinc Co. Ltd. began production at its expanded Onsan smelter. Capacity is now rated at 150 000 t/y, raising South Korea's total capacity to 225 000 t/y. The Cajamarquilla smelter in Peru had a difficult year, having to declare force majeure twice. Disruptions were first the result of technical difficulties and later, labour problems. In Thailand, the Tak smelter was expanded by 10 000 t to 70 000 t/y. In the United States, Fluor Corporation announced in September that the zinc operations of St. Joe Minerals Corporation had been sold to Horsehead Industries Inc. for about $100 million. These facilities include two smelters, at Monaca, Pennsylvania (100 000 t/y) and at Bartlesville, Oklahoma (50 000 t/y). The deal also covers the Balmat/Pierrefont mines in the State of New York.

CONSUMPTION

Non-socialist world consumption of zinc increased again in 1987 for the fifth consecutive year. It is now in excess of 5 Mt/y. Consumption is generally increasing in all countries with the possible exception of the United States and Japan. Prospects for continued growth in galvanizing appear good as steelmakers around the world have recently made and are continuing to make major investments in coating lines. This bodes well for sustained, albeit moderate improvement in zinc consumption.

INTERNATIONAL INSTITUTIONS

International Lead Zinc Study Group

The International Lead and Zinc Study Group was formed in 1959 to provide opportunities for regular intergovernmental consultations on international trade in lead and zinc, to make such special studies of the world situation in lead and zinc as may be appropriate and to consider possible solutions to any special problems or difficulties which are unlikely to be resolved in the ordinary development of world trade. Particular attention is given to providing continuous information on the supply and demand position and its probable development.

It is now headquartered in London, England. The membership of the Group includes most major lead and zinc producing and consuming countries. While it has an extensive information gathering and dissemination role, the Group has no market intervention powers. It holds a general session each year in the fall. Member countries' delegations generally include industry representatives as advisors. It is noteworthy that China joined the organization in 1987, as did Turkey and Korea. It is the first time that China has joined an international commodity organization. Canada has been an active member since its inception.

PRICES AND STOCKS

Zinc prices on the LME opened the year at US34.5¢/lb. and slowly edged downward until April when it was becoming evident that a strike at Cominco's Trail facility was becoming more likely. In June the price reached up to 42¢ but thereafter started to fall when it was obvious that the strike was not causing undue tightness in the market. With the end of the strike, prices had fallen back to less than 34¢. Finally, for reasons that are not obvious and probably buoyed by the extraordinary performance of other nonferrous metals, prices rose in November and December to close the year around 40¢. Producer prices in North America and Europe displayed roughly similar patterns when compared on a U.S. dollar basis, although North American prices tended to be about 4¢/lb. higher. Because of the increased value of European currencies, improved prices at the end of the year were less marked in these currencies.

In 1977, total reported stocks of zinc were estimated at 1 188 000 t. After falling rapidly, stocks rebounded to 875 000 t in the recession year of 1981. They have fallen steadily since then and are now at about 550 000 t, 5 to 6 weeks of consumption. This level is considered to be adequate. Zinc stocks on the LME oscillated around 30 000 t throughout the year. Producers normally hold about 65% of total reported metal stocks.

USES

Zinc is a widely used metal, based on its low melting point which facilitates shaping by casting; its high electrochemical activity which provides cathodic corrosion and contact protection (galvanizing) for iron and steel products; and its ability to alloy readily with copper to make brass. About 40% of zinc is used in galvanizing. Galvanized products such as main structural components, roofing, siding and reinforcing bars are used in construction. The use of galvanized sheet in automobile body components is also growing. Brass and bronze, as used in products such as plumbing fittings and the heating components, account for about 20% of zinc consumption, as does the diecasting industry for products such as builders' hardware and fittings on automobiles. The balance is used for such items as zinc semi-manufactures, chemicals and dust.

The first copper-plated zinc penny was struck by the U.S. Mint in November 1981 and placed in circulation in January 1982. The penny blanks are made of an alloy containing 99.2% SHG zinc and 0.8% copper; the total penny including plating is 97.6% zinc and 2.4% copper. This new usage for zinc has been consuming about 30 000 to 35 000 t/y of zinc. Although reported to be down somewhat in 1986, it is expected to be over 40 000 t in 1987. The results of regular tenders for zinc conducted by the Mint are looked upon by many as a barometer of the zinc market.

Galfan, a new and improved galvanizing alloy developed by the International Lead and Zinc Research Organization Inc. (ILZRO), was first used commercially in 1983 in Japan. The alloy contains about 90% zinc, 5% aluminum and a small but significant amount of rare earth metals. The new alloy outperforms conventional galvanizing and Galvalume in corrosion resistance and several other characteristics. Another advantage is that only minor modifications are necessary to adapt existing galvanizing lines compared with the major cost of converting a line for Galvalume. Galvalume (55% aluminum, 43.4% zinc and 1.6% silicon), developed by

Bethlehem Steel Corporation, was introduced to the U.S. market in 1976 and is being used in specialized applications. These alloys are complementary to galvanizing and increase the potential market for zinc.

OUTLOOK

Short-term

Overcapacity in the European smelting industry continues to plague the industry. The rise in the value of European currencies will put added pressure on these producers and some may decide to shut down. Such closures could have a positive effect on prices, particularly if mining capacity was adjusted accordingly. Smelting capacity is bound to move further towards concentrate-producing as well as developing countries. Mine production should fall somewhat in 1988 after a rapid increase in 1987. The market will remain well supplied in the coming years, especially with the beginning of production at Cominco's Red Dog mine in Alaska. Price levels in 1988 should remain above 1987 levels if world economies continue to grow at present rates. A recession would depress prices. Mine production in Canada will fall in 1988 with the closing at Pine Point. Metal production should however increase substantially since no labour disruptions appear likely. Pressure will remain on the industry to reduce costs and maintain low inventory levels.

Long-term

Canadian zinc mining production is expected to remain fairly constant to the turn of the century. Major mines will close (Pine Point, Sullivan) as well as several smaller ones. There are however new mines under development (Winston Lake, Isle Dieu, Caribou, etc.) and potential for future ones which should compensate for most if not all the losses. However, opening of new mines in Canada in the early 1990s could slow down as markets will have to absorb the large production increase from Red Dog in Alaska.

There is a possibility of a moderate increase in smelting and refining capacity in Canada to meet growing world demand.

Zinc consumption in the western world is projected to grow at 1.5%/y to the end of the century, which is much lower than historical growth rates. Factors underlying this relatively low forecast growth are the maturing of zinc markets in industrialized countries and expected slower world economic growth. Indeed, most consumption growth is expected to occur in developing countries.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(% unless otherwise specified)		
CANADA					
32900-1	Zinc in ores and concentrates	free	free	free	free
34500-1	Zinc dross and zinc scrap for remelting, or for processing into zinc dust	free	free	10	free
34505-1	Zinc spelter, zinc and zinc alloys containing not more than 10% by weight of other metal or metals, in the form of pigs, slabs, blocks, dust or granules	free	free	2¢/lb	free
35800-1	Zinc anodes	free	free	10	free
UNITED STATES (MFN)					
626.04	Zinc, unwrought, alloyed		19.0		
602.20	Zinc in ores and concentrates		0.3¢/lb		
626.02	Zinc, unwrought, unalloyed		1.5		
626.10	Zinc, waste and scrap (duty temporarily suspended)		2.1		

EUROPEAN ECONOMIC COMMUNITY (MFN)		1987	Base Rate	Concession Rate
26.01	Zinc, ores and concentrates	free	free	free
79.01	Zinc, unwrought	3.5	3.5	3.5
	Zinc, waste and scrap	free	free	free
JAPAN (MFN)				
26.01	Zinc, ores and concentrates	free	free	free
79.01	Zinc, unwrought, unalloyed, containing not less than 95% but not more than 97% by weight of zinc	2.2	2.5	2.1
	Zinc, unwrought, alloyed	7.2 yen/kg	10 yen/kg	7 yen/kg
	Zinc, waste and scrap	1.9	2.5	1.9

Sources: The Customs Tariff, 1987, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1987), USITC Publication 1910; U.S. Federal Register Vol. 44, No. 241; Official Journal of the European Communities, Vol. 29, No. L 345, 1986; Customs Tariff Schedules of Japan, 1987.

TABLE 1. CANADA, ZINC PRODUCTION AND TRADE, 1985-87 AND CONSUMPTION 1985 AND 1986

	1985		1986		1987P	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Production						
All forms[1]						
Ontario	280 475	351 716	265 248	322 276	323 057	411 574
New Brunswick	197 503	247 669	161 807	196 595	261 410	333 036
Northwest Territories	284 223	356 415	265 073	322 064	327 653	417 429
British Columbia	108 072	135 552	137 583	167 163	118 656	151 168
Manitoba	64 689	81 120	61 463	74 677	66 164	84 294
Quebec	75 812	95 068	37 126	45 108	93 200	118 737
Newfoundland	32 730	41 043	5 712	6 940	13 358	17 018
Saskatchewan	5 663	7 101	3 527	4 286	1 431	1 823
Yukon	108	136	50 634	61 521	154 479	196 806
Total	1 049 275	1 315 791	988 173	1 200 630	1 359 408	1 731 885
Mine output[2]	1 172 238		1 290 765		1 494 000	
Refined[3]	692 406		570 981		610 474	
Exports					(Jan.-Sept.)	
Zinc blocks, pigs and slabs						
United States	371 156	438 913	333 123	344 577	258 770	276 369
People's Republic of China	44 059	44 960	2 281	2 253	6 381	5 541
United Kingdom	41 089	44 191	29 068	28 881	19 184	19 251
Taiwan	10 776	11 735	13 245	12 267	8 557	8 652
West Germany	4 509	5 269	767	673	36	21
New Zealand	5 761	5 714	4 683	3 807	977	1 408
Philippines	3 307	3 551	4 083	3 561	2 285	2 260
Thailand	2 953	3 386	34	39	119	123
India	11 836	13 221	3 741	3 106	-	-
Hong Kong	5 636	6 782	5 685	5 500	1 500	1 655
Indonesia	5 578	6 212	4 871	4 723	2 917	2 941
Italy	4 124	4 281	2 640	2 249	2 771	2 627
Japan	7 211	8 158	5 090	4 943	2 084	2 032
Singapore	852	974	1 491	1 353	3 333	3 273
Other countries	36 774	38 110	16 374	14 568	22 470	22 387
Total	555 621	635 457	427 176	432 500	331 384	348 540
Zinc contained in ores and concentrates						
Belgium-Luxembourg	185 509r	98 868r	163 546	83 001	167 069	87 391
Japan	28 060	15 749	53 852	30 600	56 124	30 405
Netherlands	2 826	1 190	-	-	-	-
West Germany	44 493	22 654	27 726	13 244	30 393	13 990
United States	45 593r	26 054r	13 393	7 022	16 661	9 557
France	29 138	16 369	43 541	21 185	41 088	19 908
United Kingdom	20 165	9 368	27 950	12 850	20 333	10 558
Italy	21 340	10 461	39 993	16 954	22 634	12 001
Algeria	3 322	2 348	-	-	-	-
Korea South	9 377	4 814	20 881	10 257	25 513	12 190
Bulgaria	-	-	5 561	3 555	3 265	1 838
Other countries	6 280	3 528	36 775	22 523	5 315	2 586
Total	396 103	211 403	433 218	221 191	388 395	200 424
Zinc alloy scrap, dross and ash[4]						
United States	7 025	4 967	7 558	4 884	6 365	4 024
West Germany	7 477	3 462	5 781	2 518	1 782	514
United Kingdom	576	266	1 072	1 297	283	160
Taiwan	860	585	6 086	3 538	5 445	2 886
Belgium-Luxembourg	274	172	108	167	521	429
Japan	353	190	52	20	-	-
Other countries	1 514	992	2 495	1 140	2 638	1 098
Total	396 103	10 634	23 152	13 564	17 034	9 111
Zinc dust and granules						
United States	5 581	7 413	3 832	5 727	3 112	4 815
Venezuela	114	204	-	-	-	-
West Germany	93	62	-	-	37	13
United Kingdom	19	31	-	-	35	21
Other countries	2 261	1 894	94	185	62	51
Total	8 068	9 604	3 926	5 912	3 246	4 900

TABLE 1. (cont'd.)

	1985		1986		Jan.-Sept. 1987P	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Zinc fabricated material, n.e.s.						
United States	1 234	3 672	1 048	3 982	775	2 403
United Kingdom	17	85	3	17	40	127
Other countries	28	51	75	82	3 309	3 629
Total	1 279	3 808	1 126	4 081	4 124	6 159
Imports						
In ores, concentrates and scrap	17 120	9 291	36 485	16 854	15 798	7 583
Dust and granules	947	1 678	797	1 341	496	843
Slabs, blocks, pigs and anodes	1 814	2 127	9 319	11 011	8 712	11 063
Bars, rods, plates, strip and sheet	444	1 277	466	1 185	1 836	3 097
Slugs, discs and shells	-	-	21	13	6	4
Zinc oxide	1 304	1 565	1 626	1 365	1 510	1 333
Zinc sulphate	1 590	951	2 189	1 262	1 933	1 054
Zinc fabricated materials, n.e.s.	523	1 843	982	3 186	700	2 373
Total	23 742	18 732	51 885	36 217	30 991	27 350

	1985			1986P		
	Primary	Secondary	Total	Primary	Secondary	Total
	(tonnes)					
Consumption[5]						
Zinc used for, or in the manufacture of:						
Copper alloys (brass, bronze, etc.)	7 348)			9 973)		
Galvanizing: electro	2 980)	1 279	77 513	3 780)	3 725	79 900
hot dip	65 906)			62 422)		
Zinc die-cast alloy	14 152	X	X	12 358	X	X
Other products (including rolled and ribbon zinc, zinc oxide)	27 015	X	X	29 976	X	X
Total	117 401	5 855	123 256	118 509	7 576	126 085
Consumer stocks, year-end	11 210	697	11 907	11 427	423	11 850

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] New refined zinc produced from domestic primary materials (concentrates, slags, residues, etc.) plus estimated recoverable zinc in ores and concentrates shipped for export. [2] Zinc content of ores and concentrates produced. [3] Refined zinc produced from domestic and imported ores. [4] Gross weight. [5] Consumer survey does not represent 100% of Canadian consumption and is therefore consistently less than apparent consumption.
[P] Preliminary; [r] Revised; - Nil; n.e.s. Not elsewhere specified; X Confidential.

TABLE 2. CANADA, ZINC MINE OUTPUT, 1985-87

	1985	1986	1987P
		(tonnes)	
Maritimes Total	273 826	242 864	255 867
Quebec	72 079	53 319	95 115
Ontario	297 337	312 174	315 438
Manitoba-Saskatchewan	74 270	62 112	75 704
British Columbia	114 257	142 597	117 660
Northwest Territories and Yukon	340 469	477 627	646 197
Total	1 172 238	1 290 693	1 505 981

P Preliminary.

TABLE 3. CANADA, ZINC PRODUCTION, EXPORTS AND DOMESTIC SHIPMENTS, 1970, 1975, 1981-87

	Production		Exports		
	All Forms[1]	Refined[2]	In Ores and Concentrates	Refined	Total
			(tonnes)		
1970	1 135 714	417 906	809 248	318 834	1 128 082
1975	1 055 151	426 902	705 088	247 474	952 562
1981	911 178	618 650	516 210	453 526	969 736
1982	965 607	511 870	457 751	470 390	928 141
1983	987 713	617 033	626 178	500 448	1 126 626
1984	1 062 701	683 156	539 633	529 659	1 069 292
1985	1 049 275	692 406	396 103r	555 176	951 724r
1986	988 173	570 981	433 218	427 176[2]	860 394r
1987P	1 359 408	610 474	388 395[3]	331 384[3]	719 779[3]

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] New refined zinc produced from domestic primary materials (concentrates, slags, residues, etc.) plus estimated recoverable zinc in ores and concentrates shipped for export. [2] Refined zinc produced from domestic and imported ores. [3] January to September 1987.

P Preliminary; r Revised.

TABLE 4. WESTERN WORLD, PRIMARY ZINC STATISTICS, 1984-87

	1984	1985	1986	1987e
		(000 tonnes)		
Mine Production (Zinc Content)	5 073r	5 127r	5 078	5 312
Metal Production	4 892r	4 996r	4 855	5 045
Metal Consumption	4 724r	4 758r	4 917	5 036

Source: International Lead and Zinc Study Group.

e Estimated by Energy, Mines and Resources Canada; r Revised.

TABLE 5. WESTERN WORLD ZINC INDUSTRY, PRODUCTION AND CONSUMPTION, 1986

	Mine Production	Metal Production	Metal Consumption
	(000 tonnes)		
Europe			
Austria	16	24	33
Belgium	-	269	172
Denmark[1]	62	-	15
Finland	60	155	24
France	40	257	260
Germany F.R.	104	371	434
Greece	23	-	15
Ireland	182	-	1
Italy	26	230	232
Netherlands	-	198	54
Norway	27	90	19
Portugal	-	6	10
Spain	227	202	100
Switzerland	-	-	30
Sweden	219	-	35
United Kingdom	5	86	182
Yugoslavia	95	102	90
Total	1 086	1 990	1 706
Africa			
Algeria	14	30	21
Egypt	-	-	18
Morocco	13	-	2
Nigeria	-	-	14
South Africa[2]	136	81	83
Tunisia	4	-	1
West Africa	-	-	-
Zaire	82	64	-
Zambia	51	22	1
Others	-	-	24
Total	300	197	164
Americas			
Argentina	39	29	29
Bolivia	33	-	-
Brazil	93	130	151
Americas (cont'd)			
Canada	1 291	571	154
Chile	10	-	-
Colombia	1	-	18
Honduras	27	-	-
Mexico	285	176	92
Peru	598	156	51
United States	221	316	998
Venezuela	-	-	12
Others	-	-	30
Total	2 598	1 378	1 535
Asia			
Hong Kong	-	-	30
India	45	74	134
Indonesia	-	-	48
Iran	36	-	-
Israel	-	-	-
Japan	222	708	753
Korea, Rep.	37	126	154
Malaysia	-	-	-
Philippines	3	-	19
Taiwan	-	-	70
Thailand	66	59	47
Turkey	41	15	53
Others	4	-	110
Total	454	982	1 418
Oceania			
Australia	640	308	81
New Zealand	-	-	20
Total	640	308	101
Total non-socialist world	5 078	4 855	4 924

Source: International Lead and Zinc Study Group.

[1] Includes Greenland. [2] Includes Namibia.

- Nil.

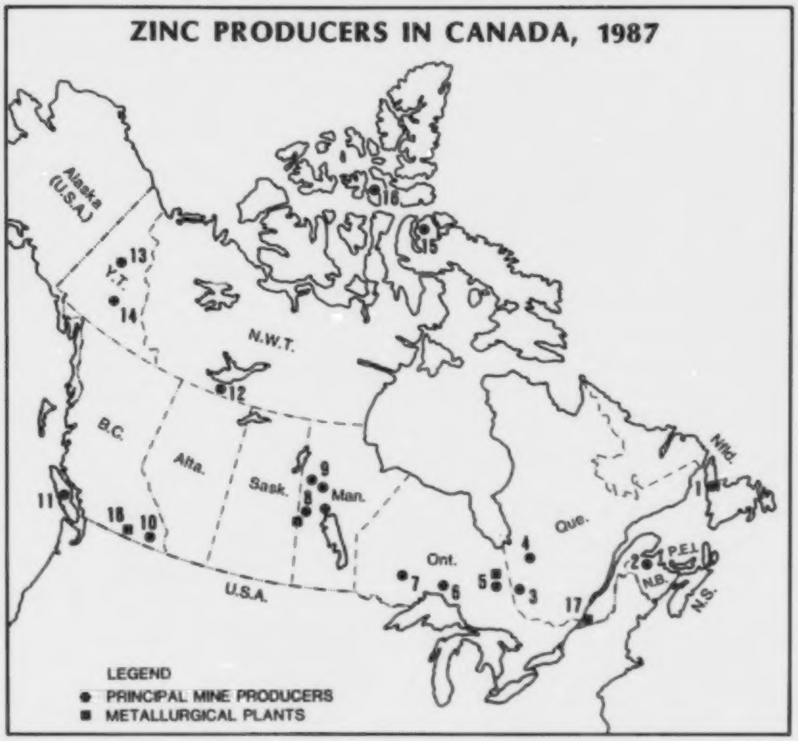
TABLE 6. CANADA, PRIMARY ZINC METAL CAPACITY, 1987

Company and Location	Annual Rated Capacity (000 tonnes of slab zinc)
Canadian Electrolytic Zinc Limited (CEZ) Valleyfield, Quebec	227
Falconbridge Limited Timmins, Ontario	133
Hudson Bay Mining and Smelting Co., Limited Flin Flon, Manitoba	73
Cominco Ltd. Trail, British Columbia	272
Canada total	705

TABLE 7. MONTHLY AVERAGE ZINC PRICES (High Grade Zinc), 1986-87

	European Producer Price (US$/tonne)	American Producer (US¢/lb.)	Canadian Producer (C¢/lb.)	LME Settlement (£/tonne)
1986				
January	700.00	32.9	45.5	452.1
February	680.50	30.9	41.9	425.8
March	670.00	31.2	42.4	426.4
April	698.64	32.1	46.0	440.5
May	738.18	33.0	48.0	465.0
June	817.14	36.5	53.3	533.1
July	840.71	39.5	60.5	535.6
August	845.71	40.8	60.5	549.4
September	901.82	43.6	63.2	592.6
October	920.00	46.0	66.1	621.3
November	910.00	45.9	67.3	575.9
December	870.00	43.5	59.8	554.6
Year Average	799.33	38.0	54.5	514.4
1987				
January	822.50	41.4	55.6	504.6
February	770.00	38.4	50.5	484.5
March	770.00	37.7	49.7	459.5
April	770.00	38.2	50.0	467.1
May	817.00	42.2	58.6	503.2
June	830.00	45.0	63.2	539.3
July	860.00	45.7	64.0	515.7
August	860.00	44.4	64.0	502.6
September	820.00	42.6	58.4	460.1
October	820.00	41.7	56.5	463.2
November	830.00	42.4	58.0	477.6
December	860.00	43.3	59.0	473.7
Year Average	819.10	41.9	57.3	487.6

Sources: Metals Week, ILZSG, Northern Miner.



ZINC PRODUCERS IN CANADA, 1987

Alaska (U.S.A.)
Y.T.
N.W.T.
B.C.
Alta.
Sask.
Man.
Ont.
Que.
Nfld.
P.E.I.
N.B.
N.S.
U.S.A.
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
LEGEND
● PRINCIPAL MINE PRODUCERS
■ METALLURGICAL PLANTS

Principal Producers
(numbers refer to numbers on map above)

1. Newfoundland Zinc Mines Limited
2. Brunswick Mining and Smelting Corporation Limited
3. Minnova Inc., Norbec Mill
   Aubrey Resources Inc. (Mobrun mine)
4. Noranda Inc. (Matagami Division)
5. Falconbridge Limited
6. Noranda Inc. (Geco Division)
7. Mattabi Mines Limited
   Noranda Inc. (Lyon Lake)
8. Hudson Bay Mining and Smelting Co., Limited (Chisel Lake, Osborne Lake, Stall Lake, Ghost Lake, Anderson Lake, Westarm, Flin Flon, White Lake, Centennial, Trout Lake, Spruce Point)
9. Hudson Bay Mining and Smelting Co., Limited (Ruttan mine)
10. Cominco Ltd. (Sullivan mine)
    Teck Corporation (Beaverdell mine)
    Dickenson Mines Limited (Silmonac mine)
11. Westmin Resources Limited
12. Pine Point Mines Limited
13. United Keno Hill Mines Limited
14. Curragh Resources Corporation
15. Nanisivik Mines Ltd.
16. Cominco Ltd. (Polaris mine)

Metallurgical Plants

5. Falconbridge Limited, Timmins
8. Hudson Bay Mining and Smelting Co., Limited, Flin Flon
17. Canadian Electrolytic Zinc Limited, Valleyfield
18. Cominco Ltd., Trail

Zirconium and Hafnium

D.E.C. KING

Canada imports all of its zirconium needs. In terms of tonnage, zircon sand and flour are the most important. Imports fell to nearly 7 000 t in 1983 following highs in excess of 22 000 t in 1981 and 1980, then recovered to nearly 15 000 t by 1985 but declined again to 10 000 t in 1986 and 4 700 t in the first nine months of 1987. Australia is the source for about 70% of western world supply and South Africa is gaining in importance, increasing its share to about 25%. Up to 10% of Canadian zircon imports have been re-exported to the United States in recent years.

The value of zirconium metal and alloy imports has exceeded that of zircon for a number of years by factors of from 5:1 to 10:1, and has generally amounted to between $16 and $20 million. A major portion of these products came from the United States and most of the remainder was imported from France.

Ferrozirconium, used as an additive in special steels to control sulphides, was a distant second in import value at about $2.5 million. Most is imported from the United States, but it is also imported from France in substantial quantities in times of dollar strength.

Canada also imports small quantities of zirconium oxide, zirconium silicate, and zirconia-alumina-silica bricks.

CANADIAN DEVELOPMENTS

In 1985, Iron Ore Company of Canada (IOC) suspended evaluation studies and research on its zirconium-rare earth property at Strange Lake, Labrador/Quebec, as a result of a market study. Studies were reopened during 1987 in response to an apparent world shortage of yttrium and zirconium. The deposit, some 300 km northeast of Schefferville, Quebec, occurs in a granite complex of pre-cambrian age and could be mined by open-pit. It might be one of the world's largest high-grade deposits of yttrium and zirconium, exhibiting both coarse and fine mineralization in several zones. The deposit also contains significant values of beryllium, niobum and the rare earth elements. Measured reserves are large and these could be increased when required. The zirconium is in the form of gittinsite, armstrongite and elpidite, acid-soluble minerals from which the metals can be separated as compounds by solvent extraction. Zirconia produced in this way would be suitable for the production of high-technology zirconia material and parts, providing that effective purity and particle size control were to be achieved during processing.

The Athabasca tar sands of Alberta are a potential source of ilmenite, rutile, and zircon. These heavy minerals tend to become concentrated in a fraction called Scroll tailings during the bitumen extraction process. A Syncrude Canada Ltd. study carried out in 1976 showed that zircon minerals of marketable quality could be separated from the other heavy minerals and that a 135 000 bbl/d Syncrude oil plant could potentially produce about 41 000 t/y of zircon and 94 000 t/y of titanium minerals. The tar sand operation of Suncor Inc. has about 40% of the oil capacity of Syncrude and represents a further potential source of zircon production, although no estimates of potential heavy mineral recovery at Suncor are available. Expansions of the tar sands operations, announced during 1987, could increase the quantity of zircon potentially available from the tar sands.

Projects for the construction of Canadian nuclear reactors that were planned prior to 1982 have remained on schedule. The initial inventory of zirconium alloy tubing for sheathing the fuel rods, in Ontario Hydro's Bruce 7 and 8 reactors and Darlington 1 to 4 reactors, was estimated at about 200 t in finished weight. Fuel replacement in 1985 required about 140 t of zirconium alloy tubes for fuel sheathing. In 1987, 230 t of sheathing alloy were installed and annual requirements were not expected to grow much above that quantity. The re-tubing of Pickering 1 and 2 reactors has been completed and plans were made to

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re-tube at least four more reactors, using stronger alloy and with a more efficient spacing design to guard against warping. This replacement will begin with two reactors in the late 1990s at the Bruce Power Station on Lake Huron.

Zirconium sponge and primary billets are produced in Canada. Precision fabrication of zirconium fuel sheaths and cooling tubes is carried out in Canada by several companies using imported semifabricated tube-hollows.

WORLD PRODUCTION AND DEVELOPMENTS

Zircon is a natural zirconium-hafnium silicate occurring widely in beach sand formations in various countries. It is by far the most important zirconium mineral. Australia is the dominant supplier of zircon concentrates but its share of world production has declined over the past several years. South Africa's share has increased as the output of Richards Bay Minerals (RBM), which began production in late-1977, has expanded. The United States is also a major producer but it has not released production statistics in recent years.

A strong demand for zirconium raw materials has prevailed since 1983 and concentrates have been in short supply during and after 1986. World zircon stockpiles became virtually depleted and Australian production output fell by 12% in 1986, compared with the 1984 level, because mineral sands containing lower zircon grades were being treated.

Mineral sands are primarily processed for titanium minerals, with zircon and monazite as by-products. The production of zircon from mineral sands is, therefore, dependent on ilmenite output, which has grown since 1984 in response to a strong demand for titanium dioxide. Baddeleyite, a zirconium oxide mineral, is a by-product of copper production at Palabora in South Africa. At the present time no primary zirconium mineral production exists anywhere.

The demand for zircon concentrates has expanded because of a trend towards the increase of new uses for zirconium materials. Since 1983, the relative proportions of zirconium used in foundry materials, refractories and ceramics in the United States has changed from about 41:28:21 to approximately 30:30:30, respectively. This relative increased emphasis on refractory and ceramic applications, compared with foundry uses, is reflected in the enlarged number of companies that have entered the lucrative ceramics market.

There is potential for an expansion in zirconium demand in the area of advanced ceramics. However, the sources of zirconium supply are still constrained by coproduction with titanium minerals.

Australia

Australia remained the world's largest zircon producer. The centre of mineral sand production has shifted from the east coast to Western Australia over the past several years, mainly due to environmental and preservation restrictions at the eastern sites. About 67-74% of its zircon output comes from Western Australia, although the highest qualitities of zircon are produced on the east coast.

The acquisition of Allied Eneabba Ltd. by Renison Goldfields Consolidated Ltd. (RGC) was completed in early 1986, and enabled RGC, through its subsidiary, Associated Minerals Consolidated Ltd. (AMC), to rationalize the operation with its own mining and plant operations near Eneabba in Western Australia. RGC is the largest mineral sand producer in the world. It had an output of 250 000 t of zircon in 1986, about 62% of total Australian production.

The 1985 sale by AMC of its North Stradbrooke Island mineral sands operations to Consolidated Rutile Ltd. (CRL) has made CRL the second largest zircon producer. Output in 1986 was nearly 80 000 t. CRL was constructing a $5 million plant to remove chrome from stockpiled high-chrome ilmenite. Annual capacity will be 175 000 t of low-chrome ilmenite.

Mineral Deposits Ltd. (MDL), a wholly-owned subsidiary of The Broken Hill Proprietary Company Limited (BHP), commissioned its new 1 700 t/h twin dredge near Tea Gardens, New South Wales. The concentrates from this and the mining operations at Stockton are transported to the existing dry processing plant at Hawks Nest, which is designed for the production of premium quality zircon and has a capacity of 30 000 t/y.

Completed feasibility studies by TiO_2 Corporation NL at Cooljarloo indicated 12 Mt of heavy minerals at a 2% cut-off grade. Accordingly, the company was in a position to begin detail design. The adjoining Jurien deposit, which is rich in rutile but smaller in overall size, was estimated to contain 2 Mt of heavy minerals at a 3% cut-off grade.

A new zirconia powder pilot plant was completed in late 1987 at the Commonwealth Scientific and Industrial Research Organization (CSIRO) chemicals division in Port Melbourne, Victoria as the first step towards a full scale plant at Rockingham, Western Australia. The $13 million commercial plant will have capacity to produce 450 t/y of high purity zirconia powder and 250 t/y zirconium chemicals. It is to be a joint venture between ICI Australia Ltd. (ICIA) and CSIRO, and will be registered as Z-Tech Pty. Ltd. The joint venture principals have already arranged marketing to cover the United States, Japan, South Korea, Taiwan and Europe. They have also agreed to market the ceramic auxiliary chemicals of Fratelli Lamberti SpA of Italy. In 1986, ICIA acquired the zirconia operation of Ferro Corporation at Bow, N.H., United States, which produces zirconia grades suitable for electronics, engineering, ceramic colours, welding fluxes and grinding media.

United States

Corning Glass Works was reported to have signed an agreement to sell two plants in Wisconsin and Ohio to Didier-Werke AG, which manufactures refractories in Wiesbaden, West Germany. The sale, subject to government approvals, is to be completed in early 1988. The two plants produce ceramic crucibles, nozzles and other products from zirconia for use in the metal-producing and glass industries.

Plans were announced by Mineral Recovery Inc. (MRI) to produce about 30 000 t/y of zircon from the treatment of 1.5 Mt of tailings that remain at ASARCO Incorporated's ilmenite operation. The latter was closed in 1981. This production is expected to last 4 to 5 years, after which dredging may yield a further 15 000 t/y of zircon, together with titanium minerals, for another 17 years. The zircon will be purchased and marketed exclusively by F&S Alloys and Minerals Corp. of New York.

Japan

Nippon Mining Company Limited completed the installation of production facilities for 500 t/y of fused zirconia at Toyama in the spring of 1986. Sales of 300-400 t of zirconia were expected in the first year of production. Its technology is based on electrofusion. In addition, Nippon has installed a pilot plant for very high purity zirconia for use in fine ceramics.

France

Pechiney S.A. was scheduled to start up a plant for the production of ultra-fine zirconia powders at Jarrie. Plant capacity was reported to be 80 t/y and the product was to be sold for use in ceramic coatings and cutting tools.

USES

Foundry sands, refractories and ceramics account for about 84% of all world zirconium mineral demand, although the consumption patterns vary from region to region.

Foundry applications, in sand form for cores or as mould washes, take advantage of zircon's low reactivity, high thermal conductivity and its chemical stability in the presence of molten metals. However, substitution by other materials tends to occur whenever there is a significant increase in the price of zircon.

The extensive use of zircon-based refractories developed first in Japan where these refractories were used in the lining of steel ladles, furnaces and crucibles, especially in continuous casting applications. Until the past several years, the majority of U.S. consumption was in foundries but, following the developments in Japan, there has since been a trend towards greater use in refractories. In 1986, consumption as foundry sands had slipped to 35% of total zircon consumed in the United States.

Zircon is the main opacifying agent in ceramic glazes and enamels. The demand for such general ceramic applications is highest in western Europe.

The total world production of baddeleyite and manufactured zirconia in 1986 was estimated to have been about 19 000 t and 8 000 t, respectively. The uses for baddeleyite are in the manufacture of zirconium oxide and alumina-zirconia (AZ) abrasives, refractories and ceramic colours. North America is the principle source of AZ abrasives.

There is a growing market for high purity manufactured zirconia for use in functional and structural ceramics. Added value is high for specialized fine zirconia powders and downstream manufactured products. Zirconia or zirconium compounds are used in oxygen sensors for exhaust systems and other industrial applications, for peizoelectric materials, in electronic applications, and wear and heat resistant coatings and inserts. Other uses for which long-term growth has been predicted include partially stabilized zirconia in engines. The future for the latter application is uncertain but, if realized, could conceivably involve large volumes. More immediately, investigations have revealed a potential for zirconia coatings on metal parts for wear resistance, and thermal and corrosion protection.

Less than 1% of all zircon produced is used to make zirconium sponge and mill products, for which the main demand is zirconium alloy tubes to hold uranium fuel rods in nuclear reactors. Because of its low neutron absorption, the zirconium tubes allow neutrons to pass through without significantly slowing them down.

Zirconium is an essential element in magnesium alloys, which are used in precision castings for the aerospace industry. Such alloys are produced and cast in Canada using imported zirconium master alloys.

TECHNOLOGICAL DEVELOPMENTS

The development of advanced ceramic materials continued to be the subject of considerable industrial research and development, particularly in Japan and the United States. The United Kingdom and other western Europe countries were pioneers in this field in the 1950s and 1960s, but allowed their lead to slip away and are now attempting to recover lost ground. Activity in this field is also under way in other countries including Australia, Brazil and Canada. Special zirconia ceramics are a group of materials now undergoing rapid growth in demand.

Researchers have identified the benefits in efficiency that would accrue from using partially stabilized zirconia ceramic parts in the hot zones of diesel and turbine engines. However, the fulfillment of the most ambitious applications may not be achieved except perhaps in the long term. These special ceramics generally possess high strength, hardness and toughness, in addition to high resistance to elevated temperatures and thermal shock. However, more development is needed in order to approach the necessary toughness levels and resistance to mechanical shock afforded by metals if ceramics are to be used to make moving parts for engines. Nevertheless, there are many potential uses for structural ceramic components in less highly stressed service requirements.

Technology for producing ceramic components is analogous to powder metallurgy. Fine and closely sized powder mixtures of approximately one micron particle size are compressed and bonded by heat. Techniques for arriving at a final bonded form include hot pressing, hot isostatic pressing (HIP), cold isostatic pressing, die-pressing, extrusion, injection moulding and slip casting.

Where ceramics cannot supply the necessary toughness, a metal substrate may be given some of the heat and abrasion resistance advantages of structural ceramics by using flame, plasma or electron beams to apply a spray coating or vapour deposition of ceramic on the metal substrate. Ceramic coatings on metal, using titanium carbide and nitride, are becoming increasingly used in cutting tools.

Mazda was reported to be using a ceramic seal between the aluminum rotor and side wall in its rotary engine to improve thermal efficiency by 10%, and ceramic coatings on the rotor recess, mixture intakes and side housing faces. The choice of ceramics can include zirconia, alumina, silicon nitride, silicon carbide, sialon and others. Zirconia compares favourably in mechanical and heat properties with its rivals, and its coefficient of expansion is more compatible with certain metals although its cost is generally higher. The raw material component of cost is about 50% to 60% of the cost of the finished ceramic part.

The Garrett Automotive group of Allied-Signal Inc. of Torrance, Calif. has been reported to be making ceramic rotors for turbine engines using silicon nitride. Sumitomo Electric Industries has developed a bonding technology for ceramic on steel involving ion-plating and multi-layer metalizing. The Pratt & Whitney Group revealed in 1987 that it has, for the first time, installed a ceramic part made by Norton-TRW Ceramics in one of its gas turbine engines. The part, sandwiched between platinum and superalloy, is located in a low-risk area subject to little stress. Chromalloy Gas Turbine Corp. is also active in developing coatings for superalloy parts. Of the ceramic coatings Chromalloy has developed for heat resistance, only one, combining yttria and stabilized zirconia, is used commercially.

Alcan Aluminium Corporation of Cambridge, Massachusetts and Lanxide Inc. of Newark, Delaware announced in 1986 a joint venture pilot plant to produce ceramic pump and valve components. This joint venture was registered under the name Alanx Products Co. The prototype components would be tested for abrasive and corrosive applications.

Organizations that have been established in Canada to promote research and development on functional and structural ceramics are: "Canadian Advanced Industrial Materials Forum", sponsored by the Canadian Manufacturer's Association, "Canadian University - Industry Council on Advanced Ceramics", and "Canadian Ceramics Society". About 20 companies in Canada manufacture functional ceramics, including IBM Canada Ltd., Murata Erie North America, Ltd. and Northern Telecom Limited. Functional ceramics include electronic capacitors, piezoelectric devices, ionic conductors, optical sensors and integrated optics.

Canadian companies involved in structural ceramics are Hamilton Porcelains Limited and Electrofuel Manufacturing Co. Fine ceramic powders are made by Alcan, Electrofuel, Northern Pigment and Kennametal Ltd., and coarse materials are made by several other firms for the manufacture of abrasives.

PRICES

Zircon prices quoted in Metals Week and American Metal Market at the end of 1987.

	Price (US$)
Zirconium ore, per short ton	
Australia	155
United States	165
Sponge, per kg	26.456-37.479
Zirconium, sheet, strip,	
bar, per kg	35.27-99.20
powder, per kg	132-330

In 1987, transaction prices of zircon concentrates rose by nearly 13% for standard zircon, 16% for intermediate grade, and 25% for premium grade.

OUTLOOK

The current tightness in supply of zircon concentrates, unless relieved by expansions or new developments, may prove to be a constraint to new applications that are evolving from continued research and development in a number of countries. Some of these applications may present investment opportunities in Canada. Advanced ceramics offer the most potential, more so in terms of value than quantity because of the very high added value involved.

The demand for zirconium alloys for nuclear purposes will be affected by the decline in the construction of commercial power reactors. However, this downward tendency will be buffered by the periodic need to replace tubes in existing reactors and by the use of zirconium alloys in the power units of nuclear submarines.

Zirconium metal production capacity is expected to exceed demand over the near and medium terms.

HAFNIUM

Zirconium and hafnium are always associated in nature, usually in the ratio of about 50:1, and they are chemically very similar. However, zirconium's low neutron absorption characteristic makes it ideal for use as sheathing for nuclear fuel rods whereas hafnium has a relatively high neutron absorption, which enables its use in nuclear control rods.

The production of hafnium-free zirconium for nuclear purposes yields an adequate supply of hafnium at a relatively stable price. Its market is largely limited to civilian and military nuclear control rods and as a minor additive to nickel based superalloys. Hafnium is also used in special ceramics, refractories and alloys. The total world consumption of hafnium is about 80 t/y.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
CANADA					
34720-1	Sponge and sponge briquettes, ingots, blooms, slabs, billets and castings in the rough, of zirconium or zirconium alloys for use in Canadian manufacture (expires June 30, 1987)	free	free	25	free
34730-1	Bars, rods, plate, sheet, strip, wire, forgings, castings, foils and tubes, seamless or welded, of zirconium or zirconium alloys for use in the manufacture of nuclear power reactors, including fuels components (expires June 30, 1987)	free	free	25	free
33508-1	Zirconium oxide	free	4.0	15	free
92845-4	Zirconium silicate	free	free	free	free
UNITED STATES					
601.63	Zirconium ore, (including zirconium sand)		free		
629.60	Zirconium metal, unwrought, waste other than alloys		4.2		
629.62	Zirconium, unwrought alloys		4.9		
629.65	Zirconium metal, wrought		5.5		
422.80	Zirconium oxide		3.7		
422.82	Other zirconium compounds		3.7		

EUROPEAN ECONOMIC COMMUNITY		1987	Base Rate	Concession Rate
			(%)	
26.01	Zirconium and hafnium ores	free		
28.28	Zirconium oxide	7.0	8.0	7.0
28.45	Zirconium silicates	5.7	8.8	5.7
73.02	Ferrozirconium	4.9	7.0	4.9
81.04	Zirconium metal			
	Unwrought; waste and scrap	5.0	6.0	5.0
	Wrought	9.0	10.0	9.0

Sources: Customs Tariff, 1987, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1987), USITC Publication 1910; U.S. Federal Register, Vol. 44, No. 241; Official Journal of the European Communities, Vol. 29, No. L 345, 1986.

TABLE 1. WORLD ZIRCONIUM RESERVES

	Reserves[1] (000 t Zr content)
United States	3 600
Brazil	200
Republic of South Africa	3 000
Sierra Leone	450
Madagascar	100
India	1 600
Malaysia/Thailand	100
Sri Lanka	900
Australia	7 900
U.S.S.R.	2 700
Peoples Republic of China	350
World Total (Rounded)	21 000

Source: U.S. Bureau of Mines Mineral Facts and Problems 1985 Bulletin 675.

[1] Estimates include currently economic demonstrated resources.

TABLE 2. FORECAST DEMAND FOR ZIRCONIUM ALLOY FOR CANDU NUCLEAR POWER REACTORS 1985-90

Year	Tonnes
1985	142
1986	189
1987	232
1988	234
1989	236
1990	272

TABLE 3. MAJOR CONSUMERS AND PROCESSORS OF ZIRCONIUM PRODUCTS IN CANADA

Product	Major Consumers
Zircon sand and flour	Dofasco Inc. Haley Industries Limited Abex Industries Ltd. Sidbec Foseco Canada Inc.
Zirconium oxide	Norton Company
Ferrozirconium	Dofasco Inc. Atlas Steels division of Rio Algom Limited Esco Limited
Zirconia-alumina-silica bricks	Consumers Packaging Inc. Domglas Inc.
Zirconium metal and alloys	Ontario Hydro Haley Industries Limited Nu-Tech Precision Metals Inc. Westinghouse Canada Inc. Noranda Metal Industries Limited General Electric Canada Inc. Eldorado Nuclear Limited Hydro-Quebec New Brunswick Electric Power Commission, The Combustion Engineering Canada Inc. Bristol Aerospace Limited

TABLE 4. WORLD PRODUCTION OF ZIRCON CONCENTRATES, 1983-86

	1983	1984	1985P	1986^e
		(tonnes)		
United States^e	50 000	60 000	70 000	85 000
Australia	382 310	454 540	440 000	401 890
Republic of South Africa	162 280	153 120	160 530	160 030
U.S.S.R.^{e}	81 700	81 700	86 200	86 200
India	11 390	11 790	14 800	15 970
China^e	14 970	14 970	14 970	14 970
Brazil	7 430	7 020	12 750	11 970
Sri Lanka	5 720	3 710	4 060	3 990
Malaysia	2 550	7 610	11 650	6 990
Thailand	200	290	880	880
Total	718 550	794 750	815 840	787 810

Sources: U.S. Bureau of Mines Minerals Yearbook Preprint, Zirconium and Hafnium, 1986; Mining Annual Review 1987 Nuclear Metals; Industrial Minerals.
P Preliminary; ^{e} Estimated.

TABLE 5. WORLD ZIRCON CONSUMPTION - ESTIMATED DISTRIBUTION BY USE AND REGION, 1983

	Foundry	Refractory	Ceramics	Zirconia	Other[1]	Total
			(000 tonnes)			
Western Europe	50	50	100	15	30	245
North America	60	40	10	20	25	155
Japan	30	130	10	5	5	180
Other countries[2]	15	15	25	-	5	60
Total	155	245	145	40	65	640
Percent	24	38	22	6	10	100

Source: Industrial Minerals, December 1983.
[1] Includes metal, chemicals, etc; [2] Not including the U.S.S.R. and China.
- Nil.

TABLE 6. CANADA, ZIRCONIUM IMPORTS BY COUNTRY, 1984-87

	1984		1985		1986		1987[1]	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Zircon sand and flour								
South Africa	2 007	281	1 500	228	1 958	384	-	-
Australia	10 508	1 470	17 942	2 392	6 518	1 070	3 187	722
United States	1 157	534	1 150	949	1 568	636	1 562	657
Total	13 672	2 285	14 820	3 570	10 043	2 091	4 749	1 379
Zirconium oxides								
United States	33	251	25	242	91	454	16	135
France	11	85	-	-	-	-	-	-
Japan	-	-	-	-	-	-	4	17
Total	44	336	25	242	91	454	20	152
Zirconium silicate								
United States	815	579	893	585	1 048	670	897	507
Australia	21	18	21	16	63	46	10	9
Total	836	597	914	602	1 111	716	907	517
Ferrozirconium alloys								
France	-	-	227	387	-	-	2	15
United States	440	1 036	913	2 066	1 097	2 662	787	1 626
Total	440	1 036	1 140	2 452	1 097	2 662	789	1 641
	(kg)		(kg)		(kg)		(kg)	
Zirconium, primary forms and fabricated material								
United States	16 225	1 629	37 223	1 310	4 107	174	1 921	44
West Germany	1 375	174	10 257	1 501	32	4	52	1
United Kingdom	-	-	-	-	-	-	454	51
South Africa	80 010	141	82 992	152	74 978	145	64 000	123
France	14 752	745	-	-	-	-	-	-
Japan	-	-	-	-	-	-	134	22
Total	122 308	4 003	130 472	2 963	78 117	322	66 561	241
Zirconium alloys								
United States	196 820	15 345	155 273	12 587	147 257	11 408	133 520	9 105
West Germany	-	-	3 152	400	-	-	-	-
France	30 118	1 621	80 421	4 590	77 420	5 047	57 101	4 129
United Kingdom	-	-	-	-	-	-	6 557	408
Sweden	121	21	-	-	-	-	-	-
Total	227 059	16 987	238 846	17 577	224 677	16 454	197 178	13 642

Source: Statistics Canada.
[1] January to September.
- Nil.

TABLE 7. CHEMICAL AND SIZE ANALYSIS OF ZIRCON CONCENTRATES OF TYPICAL PRODUCERS

	Australia (East Coast)		United States (Florida)		South Africa		
					Zircon		
	Standard	Premium	Standard	Premium	Standard	Premium	Baddeleyite
Chemical Guarantee							
% ZrO_2 Mn	65.5	66.0	65.0	66.0	65.0	66.0	95-97
% Fe_2O_3 Mx	0.05	0.05	0.1	0.04	0.3	0.05	0.4-1.0
% TiO_2 Mx	0.3	0.1	0.35	0.2	0.3	0.1	0.5-1.0
% Al_2O_3 Mx	0.4	0.3	2.0	0.5	0.25	0.08	0.1
Typical Screen Sizings microns (% cumulative)							
250	0	1	-	-	0.5	0.5	
180	1	6	5	-	0.7	0.7	
125	12	45	41	Traces	29.8	29.8	
90	67	95	84	56	80.0	80.0	
63	99	100	100	93	100.0	100.0	
53	100	-	-	100	-	-	

Source: Producers' Published Specifications.
Mn Minimum; Mx Maximum; - Nil.

TABLE 8. CANDU PRESSURIZED HEAVY WATER ELECTRIC GENERATING STATIONS IN OPERATION, UNDER CONSTRUCTION OR PROPOSED IN CANADA OR ABROAD

Generating Station	Location	Net Power (MW(e))	In-Service Dates (Expected)
NPD 2	Ontario	22	1962
Douglas Point	"	206	1968
Pickering 1 to 4	"	2 060	1971-73
Bruce 1 to 4	"	2 960	1977-79
Gentilly 2	Quebec	635	1983
Point Lepreau	New Brunswick	630	1983
Pickering 5 and 6	Ontario	1 032	1983-84
Pickering 7 and 8	"	1 032	1985
Bruce 6	"	830	1984
Bruce 5	"	830	1985
Bruce 7 and 8	"	1 660	1986-87
Darlington 1 to 4	"	3 524	1989-92
Wolsung 1	Korea	630	1983

Sources: Energy, Mines and Resources Canada, "Zirconium MR 202, 1983", and Uranium Preprint 1983-84; Ontario Hydro, Staff.

TABLE 9. WORLD PRODUCERS OF ZIRCONIUM SPONGE

Company	Plant Location	Annual Production Capacity		
		1978	1980	1983
			(tonnes)	
Teledyne Wah Chang Albany (TWCA)	Albany, Oregon, U.S.A.	3 500	3 500	3 600
Cezus (a subsidiary of Pechiney)	Jarrie, France	1 000	1 600	1 600
Western Zirconium Co.	Ogden, Utah, U.S.A.	-	1 400	1 350
Nippon Mining Company Limited	Toda, Japan	50	300	150
Zirconium Industry Co.	Hiratsuka, Japan	250	300	-
Total		4 800	7 100	6 700

Source: Teledyne Wah Chang.
- Nil.

TABLE 10. CANADIAN MANUFACTURERS OF ZIRCONIUM ALLOY COMPONENTS FOR CANDU REACTORS

Company	Location	Part
General Electric Canada Inc.	Peterborough, Ont.	Fuel bundle Pressure tubes
Westinghouse Canada Inc.	Port Hope, Ont. Varennes, Que.	Fuel bundle Fuel bundle
Combustion Engineering Canada Inc.	Moncton, N.B.	Fuel bundle
Noranda Metal Industries Limited	Arnprior, Ont.	Fuel cladding
Westinghouse Canada Inc.	Port Hope, Que.	Fuel cladding
Nu-Tech Precision Metals Inc.	Arnprior, Ont.	Pressure tubes
Westinghouse Canada Inc.	Port Hope, Ont.	Calandria tubes
Bristol Aerospace Limited	Winnipeg, Man.	Calandria tubes

Principal Canadian Nonferrous and Precious Metal Mine Production in 1986, with Highlights for 1987

PRINCIPAL CANADIAN NONFERROUS AND PRECIOUS METAL MINE PRODUCTION IN 1986, WITH HIGHLIGHTS FOR 1987

Company and Mine/Mill Location	Capacity (tonnes per day)	Grades of Ore Milled						Ore Milled (tonnes)	Metal Contained in All Concentrates Produced						1987 Highlights
		Cu %	Ni %	Pb %	Zn %	Ag (g/tonne)	Au (g/tonne)		Copper (tonnes)	Nickel (tonnes)	Zinc (tonnes)	Lead (tonnes)	Silver (kilograms)	Gold (kilograms)	
NEWFOUNDLAND															
Hope Brook Gold Inc. (BP Resources Canada Limited) Hope Brook mine Couteau Bay	3 000	-	-	-	-	-	4.5	-	-	-	-	-	-	-	Production began August 1987 from open-pit - heap leach operation. Underground production to start in 1988.
Newfoundland Zinc Mines Limited Daniel's Harbour	1 500	-	-	-	6.60	-	-	183 907	-	-	11 575	-	-	-	Mine closed April 1986, reopened September 1987.
NOVA SCOTIA															
Seabright Resources Inc.															
Forest Hill	110	-	-	-	-	-	8.4	-	-	-	-	-	-	-	Ore to be milled at Gays River with eventual capacity of 700 t/d. Western Mining Corporation Holdings Limited offered at end of 1987 to purchase all shares of Seabright.
Beaver Dam	220	-	-	-	-	-	9.6	-	-	-	-	-	-	-	
NEW BRUNSWICK															
Brunswick Mining and Smelting Corporation Limited, No. 12 mine Bathurst	10 000	0.34	-	3.46	8.73	98.1	0.63	3 400 645	9 328	-	240 483	91 234	247 830	116	
Gordex Minerals Limited Cape Spencer	500	-	-	-	-	0.31	1.80	43 832	-	-	-	-	90	55	Converting to vat leaching for year round operation.
QUEBEC															
Agnico-Eagle Mines Limited Joutel	1 630	-	-	-	-	1.30	6.00	439 126	-	-	-	-	508	2 352	

American Barrick Resources Corporation Camflo Division Val-d'Or	1 180	-	-	-	-	0.17	3.29	425 929	-	-	-	-	68	1 321	
Audrey Resources Inc. Mobrun mine	1 100	-	-	-	-	-	-	-	-	-	-	-	-	-	Mine started July 1987. Ore handled by Minnova Inc.'s Norbec mill.
Bachelor Lake Gold Mines Inc. Desmaraisville	450	-	-	-	-	0.45	5.42	123 849	-	-	-	-	52	629	
Belmoral Mines Ltd. Ferderber mine Dumont mine Val-d'Or	1 225	-	-	-	-	0.69	5.86	302 953	-	-	-	-	193	1 668	
BP Canada Inc. Les Mines Selbaie joint venture Joutel	6 500	2.35	-	-	1.06	57.4	1.09	816 387	18 249	-	7 537	-	35 873	798	Decision to mine A2 underground reserves announced.
Cambior inc. Yvan Vezina mine Rouyn	1 000	-	-	-	-	1.5	3.84	242 423	-	-	-	-	325	867	
Campbell Resources Inc./ Weston Lake Resources Inc. Joe Mann mine Chibougamau	700	0.3	-	-	-	-	6.9	-	-	-	-	-	-	-	Mine startup April 1987, ore milled at Camchib mill.
Campbell Resources Inc. Chibougamau	3 175	1.24	-	-	-	7.3	3.32	273 170	3 290	-	-	-	1 123	777	
D'Or Val Mines Ltd. Beacon mine Val d'Or	450 (mine)	-	-	-	-	-	4.4	-	-	-	-	-	-	-	Production began April 1987; 1200 t/d mill has capacity for custom feed.
Kiena Gold Mines Limited Val-d'Or	1 250	-	-	-	-	0.90	5.19	453 708	-	-	-	-	386	2 261	
Lac Minerals Ltd. Doyon Division Cadillac	1 360	-	-	-	-	0.7	7.05	478 860	-	-	-	-	305	3 163	Increasing mill capacity to 3 000 t/d.
Est-Malartic Division Malartic	1 720	-	-	-	-	0.6	4.84	682 217	-	-	-	-	400	3 035	
Terrains Aurifères Division Cadillac	1 810	-	-	-	-	1.5	4.46	557 217	-	-	-	-	771	2 277	

Principal Canadian Nonferrous and Precious Metal Mine Production in 1986, with Highlights for 1987 (cont'd)

Company and Mine/Mill Location	Capacity	Grades of Ore Milled						Ore Milled	Metal Contained in All Concentrates Produced						1987 Highlights
		Cu	Ni	Pb	Zn	Ag	Au		Copper	Nickel	Zinc	Lead	Silver	Gold	
	(tonnes per day)	%	%	%	%	(g/tonne)		(tonnes)			(tonnes)		(kilograms)		
QUEBEC (cont'd)															
Minnova Inc. Lake Dufault Division Millenbach and Corbet mines Noranda	1 540	2.57	-	-	1.37	18.5	0.71	346 095	8 626	-	3 970	-	4 845	196	Formerly Corporation Falconbridge Copper. Lake Dufault mine closed September 1986.
Lake Shortt Division Desmaraisville	1 150	-	-	-	-	0.2	5.31	399 648	-	-	-	-	99	1 992	
Opemiska Division Perry, Springer & Cooke mines, Chapais	2 720	1.21	-	-	-	8.9	2.81	460 607	5 418	-	-	-	3 477	1 158	
Muscocho Explorations Ltd. Montauban mine Montauban	375	-	-	-	-	23.0	3.04	123 500	-	-	-	-	1 230	434	
Noranda Inc. Division Mines Gaspé E-32 zone and Needle Mountain mine Murdochville	3 720	1.38	-	-	-	5.9	0.07	1 178 988	15 859	-	-	-	5 161	20	E-32 orebody commenced operation late 1986. Fire in April 1987 resulted in suspension of operation.
Horne Division Rouyn-Noranda	3 450	-	-	-	-	2.98	3.05	343 987	-	-	-	-	94	86	Production suspended early 1986.
Mattagami Division Matagami	3 950	1.16	-	-	4.96	23.7	0.38	1 007 995	9 935	-	42 896	-	9 360	150	Isle Dieu mine being developed to replace Mattagami mine due to close in 1988.
Northgate Mines Inc. Copper Rand and Portage mines Chibougamau	2 960	1.59	-	-	-	8.4	4.73	590 262	9 093	-	-	-	3 253	2 511	Western Mining Corporation Holdings Limited offered at the end of 1987 to purchase the company from parent Northgate Exploration Limited.

Sigma Mines (Quebec) Limited Val-d'Or	1 270	-	-	-	-	0.8	4.56	473 444	-	-	-	-	346	2 013	
Société québécoise d'exploration minière (SOQUEM) Val-d'Or	545	-	-	-	-	0.5	6.54	190 502	-	-	-	-	95	1 184	Sold to Cambior inc. in 1986.
ONTARIO															
Agnico-Eagle Mines Limited Silver Division Cobalt	360	-	-	-	-	-	-	-	-	-	-	-	-	-	Penn mill destroyed early 1986. Rebuilt in mid-1987.
Dickenson-Sullivan Joint Venture Red Lake	730	-	-	-	-	1.4	10.87	223 983	-	-	-	-	256	2 155	
Emerald Lake Resources Inc. Golden Rose mine Sturgeon Falls	400	-	-	-	-	-	7.2	-	-	-	-	-	-	-	First gold late 1987.
Falconbridge Limited Sudbury operations															
Falconbridge and Strathcona Mills	10 342	1.26	1.26	-	-	6.86	0.16	2 800 100	33 447	29 833	-	-	9 600	192	Closed during July and August, 1987.
Timmins operations	12 247	2.97	-	0.25	5.19	81.78	-	4 504 550	129 091	-	206 417	9 298	302 282	-	
Kidd Creek Gold Hoyle Pond mine Owl Creek mine	299	-	-	-	-	3.02	20.71	90 163	-	-	-	-	285	1 952	Includes gold production at Timmins operation.
Golden Shield Resources Ltd. (Kerr Addison Mines Limited) Virginiatown	1 225	-	-	-	-	0.2	4.10	332 873	-	-	-	-	66	1 350	
Hemlo Gold Mines Inc. Golden Giant mine Marathon	3 000	-	-	-	-	0.6	11.5	733 413	-	-	-	-	294	7 917	Noranda Inc. owns 50% interest.
INCO Limited (10 mines, Sudbury area)	49 440	1.26	1.31	-	-	5.1	0.17	9 237 217	186 787	101 790	-	-	37 034	964	Closed June 29 to August 2, 1987. Hill mine reopened in May after being on standby since 1978.

Principal Canadian Nonferrous and Precious Metal Mine Production in 1986, with Highlights for 1987 (cont'd)

Company and Mine/Mill Location	Capacity	Grades of Ore Milled						Ore Milled	Metal Contained in All Concentrates Produced						1987 Highlights
		Cu	Ni	Pb	Zn	Ag	Au		Copper	Nickel	Zinc	Lead	Silver	Gold	
	(tonnes per day)	%	%	%	%	(g/tonne)		(tonnes)			(tonnes)		(kilograms)		
ONTARIO (cont'd)															
Lac Minerals Ltd. Page-Williams mine Marathon	3 000	-	-	-	-	0.6	6.45	1 229 061	-	-	-	-	647	7 252	Court dispute with International Corona Resources Ltd. not settled by end of 1987.
Macassa Division Kirkland Lake	430	-	-	-	-	2.5	14.90	158 101	-	-	-	-	383	2 282	Lake Shore mine (part of Macassa Div.) closed May 1987.
Lake Asbestos of Quebec, Ltd. Aquarius Mill	270	-	-	-	-	3.02	7.68	65 017	-	-	-	-	166	421	
Mattabi Mines Limited Mattabi and Lyon Lake mines Ignace	2 720	0.67	-	1.10	9.03	119.3	0.41	875 613	5 208	-	80 815	8 760	87 859	258	Mattabi mine to close 1988.
Noranda Inc. Geco Division Manitouwadge	3 860	1.61	-	0.26	4.80	52.1	0.13	1 244 868	19 039	-	56 243	2 140	47 923	80	
Orofino Resources Limited Scadding Twp.	140	0.09	-	-	-	-	6.93	27 678	-	-	-	-	-	156	
Pamorex Minerals Inc. Canamax Resources Inc. Bell Creek mine Timmins	300	-	-	-	-	-	5.5	-	-	-	-	-	-	-	Began operation early 1987.
Pamour Inc. Pamour Division Timmins	2 720	-	-	-	-	0.6	2.26	885 782	-	-	-	-	291	1 735	
Schumacher Division Schumacher	2 720	0.03	-	-	-	8.3	2.95	796 527	180	-	-	-	3 837	1 933	
Schumacher Go Mill Schumacher	250	-	-	-	-	-	5.69	46 514	-	-	-	-	-	198	

Placer Dome Inc.	975	-	-	-	-	2.3	21.09	356 900	-	-	-	-	786	7 128	Former Dome Mines, Limited merged with Placer Development Limited.
Red Lake mine Red Lake															
Detour Lake mine N.E. Ontario	2 500	-	-	-	-	1.03	3.65	783 357	-	-	-	-	759	2 697	Open pit closed late 1986, underground mining began late 1987.
Dome mine South Porcupine	2 722	-	-	-	-	0.7	4.59	961 707	-	-	-	-	611	4 262	
Queenston-Inco Exploration Joint Venture McBean mine Kirkland Lake	590	-	-	-	-	0.2	3.11	181 166	-	-	-	-	43	519	Operation closed mid-1986. Minor amounts of ore milled in 1987.
Royex Gold Mining Corporation - American Barrick Renabie mine Wawa	635	-	-	-	-	1.7	7.03	166 722	-	-	-	-	238	1 098	
Teck-Corona Operating Corporation David Bell mine Marathon	1 000	-	-	-	-	0.4	8.71	228 919	-	-	-	-	90	1 900	
MANITOBA															
Granges Exploration Ltd. Aberein Corporation Tartan Lake mine Flin Flon	300	-	-	-	-	-	9.5	-	-	-	-	-	-	-	Opened May 29, 1987.
Hudson Bay Mining and Smelting Co., Limited (9 mines),															
Flin Flon & Snow Lake concentrators	10 520	2.43	-	0.09	3.24	16.9	1.55	1 864 142	42 434	-	49 546	1 139	23 370	1 363	
Ruttan mine Leaf Rapids	9 070	1.63	-	-	0.90	11.2	0.77	2 000 442	30 858	-	15 276	-	12 744	812	Sold to HBM&S by Sherritt Gordon Mines Limited, July 1987.
INCO Limited Thompson underground and open pit mines Thompson district	12 700	0.24	3.11	-	-	5.14	0.10	1 682 624	3 461	48 573	-	-	6 750	186	Closed June 29 to August 2.
Pioneer Metals Corporation Puffy Lake mine Sherridon	900	-	-	-	-	-	7.2	-	-	-	-	-	-	-	Start-up late December 1987.
SherrGold Inc. MacLellan mine Flin Flon	907	-	-	-	-	15.8	5.14	81 279	-	-	-	-	566	536	

Principal Canadian Nonferrous and Precious Metal Mine Production in 1986, with Highlights for 1987 (cont'd)

Company and Mine/Mill Location	Capacity	Grades of Ore Milled						Ore Milled	Metal Contained in All Concentrates Produced						1987 Highlights
		Cu	Ni	Pb	Zn	Ag	Au		Copper	Nickel	Zinc	Lead	Silver	Gold	
	(tonnes per day)	%	%	%	%	(g/tonne)		(tonnes)	(tonnes)				(kilograms)		
SASKATCHEWAN															
Saskatchewan Mining Development Corporation Star Lake mine La Ronge	200	-	-	-	-	16.1	2.06	2 089	-	-	-	-	4	32	Commercial production early 1987.
BRITISH COLUMBIA															
Blackdome Mining Corporation Blackdome mine Williams Lake	181	-	-	-	-	102.5	26.67	36 442	-	-	-	-	2 452	927	
Brenda Mines Ltd. Peachland	27 220	0.18	-	-	-	1.8	0.03	[illegible]	17 002	-	-	-	9 160	131	Also produces molybdenum.
Broken Hill Proprietary Company Limited, The Utah Division Island Copper mine Port Hardy	46 500	0.41	-	-	-	1.6	0.20	17 404 419	59 265	-	-	-	14 276	1 835	Also produces molybdenum and rhenium.
Cominco Ltd. Copper Division Valley Copper mine Logan Lake	[illegible]	0.48	-	-	-	3.05	0.02	4 929 403	[illegible]	-	-	-	7 549	59	Data for January-June 1986. Valley Copper mine became part of Highland Valley Copper, July 1986.
Sullivan mine Kimberley	9 070	-	-	5.26	5.49	48.34	-	1 686 694	-	-	86 042	81 073	71 272	-	6 weeks summer shutdown in 1986 and 17 weeks strike summer 1987.
Dickenson Mines Limited Silvana Division Silmonac mine New Denver	110	-	-	9.96	7.15	674.4	-	21 930	-	-	1 513	2 120	14 509	-	
Gibraltar Mines Limited McLeese Lake	37 200	0.31	-	-	-	1.0	0.01	12 182 584	29 710	-	-	-	6 286	42	4 535 t/d SXEW plant started up October 1986.

Highland Valley Copper (Partnership of Cominco & Lornex) Logan Lake	111 506	0.41	-	-	-	1.9	-	20 508 290	70 962	-	-	-	19 255	456	Data for July-December 1986. Two in-pit crushers and conveyors to be completed in 1988. Also produces molybdenum.
Lornex Mining Corporation Ltd. Lornex mine Logan Lake	72 575	0.37	-	-	-	1.6	-	14 463 316	47 832	-	-	-	11 538	-	Data for January-June 1986. Lornex mine became part of Highland Valley Copper, July 1986.
Mascot Gold Mines Limited Nickel Plate mine Hedley	2 500	-	-	-	-	-	4.4	-	-	-	-	-	-	-	Open pit started mid-1987, considering underground development.
Newmont Mines Limited Similkameen Division Princeton	19 960	0.44	-	-	-	3.5	0.14	7 011 236	24 061	-	-	-	12 434	477	
Noranda Inc. Bell Copper mine Babine Lake	15 420	0.49	-	-	-	1.4	0.27	5 333 126	21 200	-	-	-	3 863	728	Mine life extended to end of 1989.
Placer Dome Inc. Equity Silver mill Houston	7 711	0.34	-	-	-	93.26	0.93	2 958 700	7 306	-	-	-	168 587	1 334	Formerly Placer Development Limited.
Taurus Resources Ltd. Cassiar area	180	-	-	-	-	1.8	4.18	33 697	-	-	-	-	33	78	
Teck Corporation Afton Operating Corporation Kamloops	6 800	0.96	-	-	-	5.4	0.82	2 693 706	21 854	-	-	-	9 791	1 814	Main pit mined out 1987, operations shifted to Pothook pit.
Beaverdell mine Beaverdell	120	-	-	0.35	0.44	320.9	-	36 120	-	-	127	104	9 762	-	
Total Erickson Resources Ltd. Cassiar	180	-	-	-	-	12.3	31.09	24 645	-	-	-	-	232	765	Mill rebuilt after fire in early 1986 expanded capacity to 300 t/d.
Westmin Resources Limited H-W, Lynx, mines Buttle Lake	2 720	2.33	-	0.47	5.85	49.4	2.47	1 066 662	23 446	-	56 240	4 347	38 967	1 570	Mill expansion to 4 000 t/d commenced 1987, due for completion third quarter 1988.
YUKON TERRITORY															
Curragh Resources Corporation Faro mine	13 500	0.16	-	3.04	4.73	41.6	0.16	1 963 436	1 461	-	71 235	42 300	42 784	146	

Principal Canadian Nonferrous and Precious Metal Mine Production in 1986, with Highlights for 1987 (cont'd)

Company and Mine/Mill Location	Capacity	Grades of Ore Milled						Ore Milled	Metal Contained in All Concentrates Produced						1987 Highlights
		Cu	Ni	Pb	Zn	Ag	Au		Copper	Nickel	Zinc	Lead	Silver	Gold	
	(tonnes per day)	%	%	%	%	(g/tonne)		(tonnes)			(tonnes)		(kilograms)		
YUKON (cont'd)															
Total Erickson Resources Ltd. Mount Skukum mine	272	-	-	-	-	10.6	13.37	77 655	-	-	-	-	715	933	
United Keno Hill Mines Limited Elsa, Husky, No Cash, Keno mines Elsa	650	-	-	3.06	0.24	859.2	-	73 596	-	-	66	1 356	53 186	-	
NORTHWEST TERRITORIES															
Cominco Ltd. Polaris mine Little Cornwallis Island	2 630	-	-	3.10	13.3	-	-	805 843	-	-	115 128	26 601	-	-	
Echo Bay Mines Ltd. Lupin mine Contwoyto Lake	1 540	-	-	-	-	1.7	10.73	590 779	-	-	-	-	976	6 102	
Giant Yellowknife Mines Limited Yellowknife Division Giant mine Yellowknife	1 090	-	-	-	-	1.6	7.82	303 053	-	-	-	-	426	2 065	
Salmita Division	160	-	-	-	-	5.1	25.13	63 380	-	-	-	-	313	1 529	Mine closed mid-1987.
Nanisivik Mines Ltd. Baffin Island	2 200	-	-	0.60	9.10	45.9	-	685 000	-	-	60 353	3 849	26 616	-	
NERCO Minerals Company Con and Rycon mines Yellowknife	660	-	-	-	-	3.8	14.4	217 724	-	-	-	-	767	2 768	
Pine Point Mines Limited Pine Point mine Pine Point	9 980	-	-	4.08	8.76	-	-	2 966 975	-	-	244 442	117 216	-	-	Mine closed mid-1987. Milling to continue to early 1988.

- Nil.

Statistical Report

The statistical material contained in this summary was principally derived from surveys conducted by the Information Systems Division of the Mineral Policy Sector of Energy, Mines and Resources Canada.

The statistical survey program of Energy, Mines and Resources Canada is conducted jointly with the provincial governments and Statistics Canada. This joint program is intended to minimize the reporting burden on the mineral companies. The cooperation of the companies that provide information is greatly appreciated. Without this cooperation, a statistical report of this nature would not be possible. International mineral statistics contained in this summary are derived from the U.S. Bureau of Mines, the American Bureau of Metal Statistics, the World Bureau of Metal Statistics, **Metals Week**, and the **Engineering and Mining Journal.**

This statistical summary of the mineral industry in Canada for the year 1987 was prepared by H.L. Martin and staff, Statistics Section, Mineral Policy Sector, Energy, Mines and Resources Canada, Ottawa. Telephone (613) 992-6439.

STATISTICAL TABLES

Table No.

Canada, general economic indicators, 1972-86.

SECTION 1: PRODUCTION

1 Mineral production of Canada, 1985 and 1986, and average 1982-86.
2 Canada, value of mineral production, per capita value of mineral production, and population, 1957-86.
3 Canada, value of mineral production by provinces, territories and mineral classes, 1986.
4 Canada, percentage contribution of leading minerals to total value of mineral production, 1980-86.
5 Canada, production of leading minerals by provinces and territories, 1986.
6 Canada, value of mineral production by provinces and territories, 1980-86.
7 Canada, percentage contribution of provinces and territories to total value of mineral production, 1980-86.
8 Canada's world role as a producer of certain important minerals, 1985.
9 Canada, census value added, total activity, mining and mineral manufacturing industries, 1979-85.
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CANADA, GENERAL ECONOMIC INDICATORS, 1972-86

		1972	1973	1974	1975	1976
Gross domestic product, current dollars	$ million	108 629	127 372	152 111	171 540	197 924
Gross domestic product, constant dollars (1981 = 100)	"	245 441	264 369	276 006	283 187	300 638
Mining's gross domestic product (1981 = 100)	"	21 548.7	25 996.4	23 775.5	19 520.7	19 585.9
Manufacturing's gross domestic product (1981 = 100)	"	48 469.6	53 679.4	55 294.4	51 600.8	55 382.1
Industrial production's gross domestic product (1981 = 100)	"	71 136.0	79 587.6	81 134.8	75 170.8	80 222.7
Value of manufacturing industry shipments	"	56 191	66 674	82 455	88 427	98 076
Value of mineral production	"	6 408	8 370	11 754	13 347	15 693
Merchandise exports	"	20 222	25 649	32 738	33 616	38 166
Merchandise imports	"	18 272	22 726	30 903	33 962	36 606
Balance of payments, current account	"	-283	312	-1 299	-4 631	-4 096
Corporation profits before taxes	"	10 799	15 417	20 062	19 663	19 985
Business investment, current dollars	"	19 926	24 588	30 370	35 602	40 462
Business investment, constant dollars (1981 = 100)	"	38 694	43 482	46 555	49 418	52 453
Population	000s	21 802	22 043	22 364	22 697	22 993
Labour force	"	8 897	9 276	9 639	9 974	10 203
Employed	"	8 344	8 761	9 125	9 284	9 477
Unemployed	"	553	515	514	690	726
Unemployment rate	per cent	6.2	5.5	5.3	6.9	7.1
Labour income	$ million	59 358	68 423	81 656	95 277	110 419
Consumer price index	1981=100	44.2	47.6	52.8	58.5	62.9

P Preliminary.

1977	1978	1979	1980	1981	1982	1983	1984	1985	1986P
217 879	241 604	276 069	309 891	355 994	374 750	405 425	443 327	476 361	505 227
311 347	325 751	338 362	343 384	355 994	344 082	354 780	374 462	389 324	401 531
18 893.7	17 878.6	20 214.6	19 660.2	17 453.2	16 462.9	17 019.1	18 968.4	19 901.4	19 000.1
57 391.2	60 006.4	62 254.4	59 460.7	61 648.1	54 844.3	57 954.3	62 200.3	65 190.5	66 255.8
82 919.9	85 798.9	89 940.6	86 879.6	88 674.7	80 910.0	84 981.6	91 963.8	96 502.3	96 894.3
109 747	129 019	152 133	165 985	190 851	183 652	200 155	225 970	244 110	249 478
18 473	20 319	26 135	31 926	32 420	33 831	38 539	43 789	44 734	33 854
44 495	53 361	65 582	76 681	84 432	84 560	90 700	112 219	120 258	120 631
41 523	49 048	61 157	67 903	77 140	66 739	73 054	91 493	102 783	110 498
-4 322	-4 903	-4 864	-1 130	-6 131	2 906	2 942	3 362	-584	-8 805
21 090	25 360	34 884	36 456	32 638	21 110	32 684	45 430	47 528	45 193
43 485	47 496	56 096	64 065	76 672	71 067	70 862	73 034	80 856	87 303
53 587	55 638	61 399	68 103	76 672	67 088	65 972	66 231	70 609	73 146
23 258	23 476	23 671	23 936	24 342	24 634	24 886	25 124	25 360	25 591
10 500	10 895	11 231	11 573	11 904	11 958	12 183	12 399	12 639	12 870
9 651	9 987	10 395	10 708	11 006	10 644	10 734	11 000	11 311	11 634
849	908	836	865	898	1 314	1 448	1 399	1 328	1 236
8.1	8.3	7.4	7.5	7.5	11.0	11.9	11.3	10.5	9.6
122 476	133 383	150 172	169 736	196 002	209 449	219 352	235 903	252 815	267 294
67.9	73.9	80.7	88.9	100.0	110.8	117.2	122.3	127.2	132.4

TABLE 1. MINERAL PRODUCTION OF CANADA, 1985 AND 1986, AND AVERAGE 1982-86

	Unit of Measure	1985		1986P		Average 1982-86	
		(Quantity)	($000)	(Quantity)	($000)	(Quantity)	($000)
Metals							
Antimony	t	1 075	6 476	3 900	23 910	1 275	7 633
Bismuth	t	201	3 943	260	2 425	214	2 131
Cadmium	t	1 717	6 245	1 421	5 434	1 420	5 368
Calcium	t	..	(1)	..	(1)	516	5 119
Cesium, pollucite, rubidium	t	..	(1)	..	(1)	117	263
Cobalt	t	2 067	71 960	2 486	56 242	1 872	50 327
Columbium (Cb_2O_5)	t	..	(1)	..	(1)	2 695	18 041
Copper	000 t	739	1 466 932	768	1 567 988	699	1 392 019
Gold	kg	87 562	1 219 653	104 655	1 715 392	82 997	1 280 772
Ilmenite	t	..	(1)	..	(1)	431 687	11 949
Indium	kg	..	(1)	..	(1)	2 779	308
Iron ore	000 t	39 502	1 462 254	36 096	1 254 758	36 338	1 334 127
Iron remelt	000 t	..	(1)	..	(1)	529 666	123 852
Lead	000 t	268	154 845	303	204 427	284	187 999
Lithium, lepidolite, spodumene	t	..	(1)	..	(1)	195	836
Magnesium	t	..	(1)	..	(1)	7 769	32 034
Molybdenum	t	7 852	74 359	12 914	113 942	10 420	100 538
Nickel	000 t	170	1 217 388	181	1 075 467	148	968 278
Platinum group	kg	10 534	(1)	8 793	(1)	8 753	116 110
Rhenium	kg	..	(1)	..	(1)	830	498
Selenium	t	361	7 869	334	5 742	329	6 097
Silver	t	1 197	333 839	1 219	310 102	1 251	413 147
Strontium	t	..	(1)	..	(1)	87	2 311
Tantalum (Ta_2O_5)	t	39	3 045	39	2 124	28	2 482
Tellurium	t	19	645	16	547	18	560
Tin	t	120	1 893	..	(1)	618	6 332
Tungsten (WO_3)	t	4 031	(1)	1 786	(1)	2 834	28 997
Uranium (U)	t	10 441	1 002 127	10 977	923 838	9 595	879 268
Yttrium (Y_2O_3)	t	..	(1)	..	(1)	..	(1)
Zinc	000 t	1 049	1 315 791	1 055	1 304 107	1 022	1 254 349
Total metals			8 709 411		8 944 159		8 231 963
Nonmetals							
Arsenious trioxide	t	..	(1)	..	(1)	2 928	870
Asbestos	000 t	750	298 596	640	300 586	784	346 909
Barite	000 t	71	5 503	37	4 635	48	4 991
Bentonite	000 t	..	(1)	..	(1)	64	3 207
Diatomite	t	..	(1)	..	(1)	2 465	155
Gemstone	t	—	823	1	2 114	—	1 020
Graphite	t	..	(1)	..	(1)	719	536

Gypsum	000 t	8 447	75 076	8 542	80 163	7 652	64 631
Magnesitic dolomite and brucite	000 t	136	20 266	144	19 165	101	12 723
Marl	000 t	..	(1)	..	(1)	10	154
Mica	000 t	..	(1)	..	(1)	11	3 742
Nepheline syenite	000 t	467	17 898	485	20 413	509	18 326
Peat	000 t	643	63 772	587	74 502	558	57 528
Perlite	t	..	(1)	..	(1)	900	100
Potash (K$_2$O)	000 t	6 661	629 546	6 969	579 022	6 552	670 476
Pumice	t	-	-	-	-	408	10
Pyrite, pyrrhotite	t	-	-	-	-	1 827	44
Quartz	000 t	2 669	42 536	2 437	42 834	2 354	39 309
Salt	000 t	10 085	215 362	11 088	241 611	9 608	199 655
Serpentine	t	..	(1)	..	(1)	3 842	491
Soapstone, talc and pyrophyllite	000 t	127	13 352	125	15 746	109	10 663
Sodium antimonate	t	..	(1)	-	-	906	459
Sodium sulphate	000 t	366	33 871	371	33 413	425	39 017
Sulphur in smelter gas	000 t	822	86 342	760	66 983	746	60 175
Sulphur, elemental	000 t	8 102	1 026 202	6 868	927 083	7 380	711 943
Titanium dioxide	000 t	..	(1)	..	(1)	604	171 506
Total nonmetals			2 737 374		2 668 790		2 418 640
Fuels							
Coal	000 t	60 436	1 845 130	57 800	1 716 000	52 647	1 590 835
Natural gas	million m^3	84 344	8 047 705	76 365	6 743 835	77 436	7 414 410
Natural gas by-products	million m^3	19 682	2 809 781	18 906	1 825 439	18 941	2 493 637
Petroleum, crude	000 m^3	85 564	18 417 806	84 964	9 719 155	81 350	14 844 427
Total fuels			31 120 422		20 004 429		26 343 309
Structural materials							
Clay products	000 $	..	138 246	..	180 353	..	136 743
Cement	000 t	10 192	788 357	10 058	790 846	9 157	727 801
Lime	000 t	2 212	182 377	2 346	206 400	2 203	169 036
Sand and gravel	000 t	256 183	609 638	242 548	596 603	236 434	585 315
Stone	000 t	86 632	406 601	91 200	426 306	77 264	360 826
Total structural materials			2 125 219		2 200 508		1 979 722
Other minerals[1]			41 114		36 511		
Total all minerals			44 733 540		33 854 397		38 973 634

Notes: (1) Other minerals include those commodities for which the value of production is confidential.
P Preliminary; .. Not available; - Nil; -- Too small to be expressed.

TABLE 2. CANADA, VALUE OF MINERAL PRODUCTION, PER CAPITA VALUE OF MINERAL PRODUCTION, AND POPULATION, 1957-86

	Metallics	Industrial Minerals	Fuels	Other Minerals[1]	Total	Per Capita Value of Mineral Production	Population of Canada
			($ million)			($)	(000)
1957	1 159	466	565		2 190	131.87	16 610
1958	1 130	460	511		2 101	122.99	17 080
1959	1 371	503	535		2 409	137.79	17 483
1960	1 407	520	566		2 493	139.48	17 870
1961	1 387	542	674		2 603	142.72	18 238
1962	1 496	574	811		2 881	155.05	18 583
1963	1 510	632	885		3 027	159.91	18 931
1964	1 702	690	973		3 365	174.45	19 291
1965	1 908	761	1 046		3 715	189.11	19 644
1966	1 985	844	1 152		3 981	198.88	20 015
1967	2 285	861	1 235		4 381	214.99	20 378
1968	2 493	886	1 343		4 722	228.10	20 701
1969	2 378	891	1 465		4 734	225.42	21 001
1970	3 073	931	1 718		5 722	268.68	21 297
1971	2 940	1 008	2 015		5 963	276.46	21 568
1972	2 956	1 085	2 367		6 408	293.92	21 802
1973	3 850	1 293	3 227		8 370	379.69	22 043
1974	4 821	1 731	5 202		11 754	525.55	22 364
1975	4 796	1 898	6 653		13 347	588.05	22 697
1976	5 315	2 269	8 109		15 693	682.51	22 993
1977	5 988	2 612	9 873		18 473	794.26	23 258
1978	5 682	2 986	11 578	73	20 319	865.51	23 476
1979	7 924	3 514	14 617	81	26 135	1 104.11	23 671
1980	9 666	4 201	17 944	115	31 926	1 333.79	23 936
1981	8 753	4 486	19 012	136	32 420	1 331.85	24 342
1982	6 874	3 709	23 038	215	33 837	1 373.59	24 634
1983	7 398	3 741	27 154	245	38 539	1 548.62	24 886
1984	8 670	4 318	30 399	401	43 789	1 742.91	25 124
1985	8 709	4 863	31 120	41	44 734	1 763.95	25 360
1986P	8 944	4 869	20 004	37	33 854	1 322.90	25 591

[1] Other minerals include arsenious trioxide, bentonite, cesium, diatomite, marl, perlite, serpentine, tin, tungsten and yttrium for which the value of production is confidential.
P Preliminary.

TABLE 3. CANADA, VALUE OF MINERAL PRODUCTION BY PROVINCES, TERRITORIES AND MINERAL CLASSES, 1986P

	Metals		Industrial minerals		Fuels		Other minerals[1]		Total	
	($000)	(% of total)	($000)	(% of total)	($000)	(% of total)	($000)	(% of total)	($000)	(% of total)
Alberta	410	x	1 185 281	24.3	16 276 734	81.4	306	0.8	17 462 731	51.6
Ontario	3 543 038	39.6	1 170 991	24.0	81 212	0.4	1 954	5.4	4 797 195	14.2
British Columbia	1 284 193	14.4	369 866	7.6	1 710 501	8.6	1 038	2.8	3 365 598	9.9
Saskatchewan	459 491	5.1	607 003	12.5	1 504 552	7.5	1 763	4.8	2 572 809	7.6
Quebec	1 253 553	14.0	1 022 197	21.0	-	-	-	-	2 275 750	6.7
Northwest Territories	630 546	7.0	13 065	0.3	133 601	0.7	12 628	34.6	789 840	2.3
Newfoundland	710 747	7.9	53 422	1.1	-	-	-	-	764 169	2.3
Manitoba	541 220	6.1	121 491	2.5	94 601	0.5	1 041	2.9	758 353	2.2
New Brunswick	346 245	3.9	153 056	3.1	26 728	0.1	17	x	526 046	1.6
Nova Scotia	-	-	162 409	3.3	176 500	0.9	17 764	48.7	356 673	1.1
Yukon	174 716	2.0	8 817	0.2	-	-	-	-	183 533	0.5
Prince Edward Island	-	-	1 700	x	-	-	-	-	1 700	x
Total	8 944 159	100.0	4 869 298	100.0	20 004 429	100.0	36 511	100.0	33 854 397	100.0

[1] Other minerals include arsenious trioxide, bentonite, cesium, diatomite, marl, perlite, serpentine, tin, tungsten and yttrium for which the value of production is confidential.
P Preliminary; - Nil; x Too small to be expressed.

TABLE 4. CANADA, PERCENTAGE CONTRIBUTION OF LEADING MINERALS TO TOTAL VALUE OF MINERAL PRODUCTION, 1980-86

	1980	1981	1982	1983	1984	1985	1986P
Oil, crude	28.4	29.2	36.0	41.8	40.6	41.2	28.7
Natural gas	19.3	19.8	21.5	18.4	18.1	18.0	19.9
Natural gas by-product	5.7	6.5	6.8	7.0	6.5	6.3	5.4
Coal	2.9	3.3	3.8	3.4	4.1	4.1	5.1
Gold	3.7	2.8	2.9	3.2	2.9	2.7	5.1
Copper	5.8	4.7	3.5	3.5	3.1	3.3	4.6
Zinc	2.7	3.4	3.1	2.9	3.4	2.9	3.9
Iron ore	5.3	5.4	3.6	3.3	3.4	3.3	3.7
Nickel	4.7	3.8	1.8	2.0	2.7	2.7	3.2
Sulphur, elemental	1.4	2.0	1.7	1.1	1.4	2.3	2.7
Uranium (U)	2.2	2.5	2.5	1.7	2.1	2.2	2.7
Cement	1.8	2.1	2.0	1.6	1.6	1.8	2.3
Sand and gravel	1.6	1.6	1.6	1.6	1.2	1.4	1.8
Potash (K_2O)	3.2	3.1	1.9	1.7	2.0	1.4	1.7
Stone	1.1	1.0	0.8	0.8	0.9	0.9	1.3
Silver	2.6	1.4	1.2	1.4	1.1	0.7	0.9
Asbestos	1.9	1.7	1.1	1.0	0.9	0.7	0.9
Salt	0.4	0.4	0.5	0.4	0.5	0.5	0.7
Lime	0.4	0.5	0.4	0.4	0.4	0.4	0.6
Lead	0.9	0.8	0.6	0.4	0.4	0.3	0.6
Clay products	0.3	0.4	0.3	0.3	0.3	0.3	0.5
Molybdenum	0.9	0.9	0.5	0.2	0.2	0.2	0.3
Other minerals	2.8	2.7	1.9	1.9	2.2	2.4	3.4
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

P Preliminary.

TABLE 5. PRODUCTION OF LEADING MINERALS, BY PROVINCES AND TERRITORIES, 1986P

	Unit of measure	Nfld.	P.E.I.	Nova Scotia	New Brunswick	Quebec	Ontario
Petroleum, crude	000 m^3	-	-	-	x	-	134
	$000	-	-	-	13	-	15 410
Natural gas	million m^3	-	-	-	1	-	504
	$000	-	-	-	15	-	65 802
Natural gas byproducts	000 m^3	-	-	-	-	-	-
	$000	-	-	-	-	-	-
Coal	000 t	-	-	2 880	480	-	-
	$000	-	-	176 500	26 700	-	-
Gold	kg	-	-	-	107	29 464	46 720
	$000	-	-	-	1 757	482 944	765 781
Copper	000 t	-	-	-	7	67	289
	$000	-	-	-	14 427	136 840	590 456
Zinc	000 t	7	-	-	166	42	304
	$000	8 264	-	-	205 308	51 912	375 187
Iron ore	000 t	19 465	-	-	-	13 200	3 367
	$000	702 483	-	-	-	..	..
Nickel	000 t	-	-	-	-	-	137
	$000	-	-	-	-	-	815 858
Sulphur, elemental	000 t	-	-	-	-	-	x
	$000	-	-	-	-	-	42
Uranium (U)	000 t	-	-	-	-	-	4
	$000	-	-	-	-	-	476 462
Cement	000 t	..	-	..	..	3 231	3 965
	$000	9 300	-	20 449	8 406	200 700	282 189
Sand and gravel	000 t	2 700	475	8 325	8 200	26 023	77 200
	$000	13 345	1 700	25 150	..	..	203 500
Potash (K$_2$O)	000 t	-	-	-	..	-	-
	$000	-	-	-	..	-	-
Stone	000 t	529	-	4 203	2 030	32 918	41 883
	$000	2 612	-	22 504	11 074	153 024	189 892
Silver	t	-	-	-	201	50	437
	$000	-	-	-	51 031	12 643	111 218
Asbestos	000 t	45	-	-	-	515	-
	$000	18 000	-	-	-	232 986	-
Salt	000 t	-	-	..	..	..	6 708
	$000	-	-	..	..	..	145 104
Lime	000 t	-	-	-	..	..	1 633
	$000	-	-	-	..	..	140 421
Lead	000 t	-	-	-	76	-	7
	$000	-	-	-	51 454	-	4 407
Clay products	$000	1 480	-	7 730	3 350	31 783	110 410
Molybdenum	t	-	-	-	-	400	-
	$000	-	-	-	-	3 529	-
Total leading minerals	$000	755 484	1 700	252 333[1]	373 535[1]	1 306 361[1]	4 292 139[1]
Total all minerals	$000	764 169	1 700	356 673	526 046	2 275 750	4 797 195
Leading minerals as per cent of all minerals		98.9	100.0	70.7	71.0	57.4	89.5

[1] Value of salt, sand and gravel, lime, potash or iron ore is excluded.
P Preliminary; - Nil; .. Not available; x Less than 1 unit.

Manitoba	Saskat-chewan	Alberta	British Columbia	Yukon	N.W.T.	Total Canada
825	11 544	68 970	2 004	-	1 487	84 964
94 601	1 269 785	7 970 208	257 620	-	111 518	9 719 155
-	2 113	67 029	6 444	-	273	76 365
-	118 334	6 106 362	431 239	-	22 083	6 743 835
-	176	18 295	435	-	-	18 906
-	16 433	1 762 164	46 842	-	-	1 825 439
-	8 270	25 020	21 150	-	-	57 800
-	100 000	438 000	974 800	-	-	1 716 000
2 187	15	25	8 737	4 020	13 380	104 655
35 851	245	410	143 208	65 890	219 306	1 715 392
69	3	-	332	x	x	768
141 389	7 051	-	677 783	41	1	1 567 988
58	3	-	138	55	284	1 055
71 369	3 972	-	170 181	67 438	350 476	1 304 107
-	-	-	64	-	-	36 096
-	-	-	3 442	-	-	1 254 758
44	-	-	-	-	-	181
259 609	-	-	-	-	-	1 075 467
1	7	6 565	295	-	-	6 868
191	770	874 186	51 895	-	-	927 083
-	7	-	-	-	-	11
-	447 376	-	-	-	-	923 838
431	..	934	1 013	-	-	10 058
46 104	20 007	124 951	78 740	-	-	790 846
12 200	10 675	48 400	41 900	3 450	3 000	242 548
35 100	26 050	108 000	106 600	8 700	4 775	596 603
-	..	-	-	-	-	6 969
-	..	-	-	-	-	579 022
3 466	-	196	5 725	-	250	91 200
13 100	-	2 925	30 275	-	900	426 306
34	3	-	405	66	23	1 219
8 707	671	-	103 093	16 897	5 842	310 102
-	-	-	80	-	-	640
-	-	-	49 600	-	-	300 586
-	442	1 391	-	-	-	11 088
-	25 397	22 203	-	-	-	241 611
..	-	191	126	-	-	2 364
5 417	-	21 437	9 954	-	-	206 400
x	-	-	103	36	81	304
334	-	-	69 514	24 436	54 282	204 427
2 480	4 060	10 160	8 900	-	-	180 353
-	-	-	12 514	-	-	12 914
-	-	-	110 413	-	-	113 943
714 252	2 040 151[1]	17 441 006	3 324 099	183 402	769 183	32 723 261
758 353	2 572 809	17 462 731	3 365 598	183 533	789 840	33 854 397
94.2	79.3	99.9	98.8	99.9	97.3	96.7

TABLE 6. CANADA, VALUE OF MINERAL PRODUCTION BY PROVINCES AND TERRITORIES, 1980-86

	1980	1981	1982	1983	1984	1985	1986P
				($ million)			
Alberta	16 379	17 559	20 913	24 103	26 429	27 030	17 463
Ontario	4 640	4 160	3 148	3 687	4 531	4 630	4 797
British Columbia	2 795	2 822	2 769	2 902	3 346	3 541	3 366
Saskatchewan	2 315	2 293	2 313	2 843	3 758	3 797	2 573
Quebec	2 467	2 420	2 065	2 039	2 167	2 243	2 275
Northwest Territories	425	447	503	595	777	865	790
Newfoundland	1 036	1 030	647	807	979	870	764
Manitoba	803	642	530	733	812	862	758
New Brunswick	373	531	493	506	613	508	526
Nova Scotia	247	269	281	260	304	325	356
Yukon	361	236	169	63	70	60	184
Prince Edward Island	2	2	2	1	2	2	2
Total	31 842	32 410	33 831	38 539	43 789	44 734	33 854

P Preliminary.

TABLE 7. CANADA, PERCENTAGE CONTRIBUTION OF PROVINCES AND TERRITORIES TO TOTAL VALUE OF MINERAL PRODUCTION, 1980-86

	1980	1981	1982	1983	1984	1985	1986P
Alberta	51.4	54.2	61.8	62.5	60.4	60.4	51.6
Ontario	14.6	12.8	9.3	9.6	10.4	10.4	14.2
British Columbia	8.8	8.7	8.2	7.5	7.6	7.9	9.9
Saskatchewan	7.2	7.0	6.8	7.4	8.6	8.5	7.6
Quebec	7.7	7.5	6.1	5.3	5.0	5.0	6.7
Northwest Territories	1.3	1.4	1.5	1.5	1.8	1.9	2.3
Newfoundland	3.3	3.2	1.9	2.1	2.2	1.9	2.3
Manitoba	2.5	2.0	1.6	1.9	1.9	1.9	2.2
New Brunswick	1.2	1.6	1.5	1.3	1.4	1.1	1.6
Nova Scotia	0.8	0.8	0.8	0.7	0.7	0.7	1.1
Yukon	1.1	0.7	0.5	0.2	0.2	0.1	0.5
Prince Edward Island	0.01	0.01	0.01	x	x	x	x
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

P Preliminary; x Too small to be expressed.

TABLE 8. CANADA'S WORLD ROLE AS A PRODUCER OF CERTAIN IMPORTANT MINERALS, 1985P

			Rank of Five Leading Countries				
		World	1	2	3	4	5
Uranium (U concentrates)[1]			**Canada**	South Africa	Australia	U.S.A.	Namibia
	t	36 499	10 666	4 908	4 500	4 308	3 693
	% of world total		29.2	13.4	12.3	11.8	10.1
Zinc (mine production)			**Canada**	U.S.S.R.	Australia	Peru	Mexico
	000 t	6 917	1 172	1 000	743	583	312
	% of world total		16.9	14.5	10.7	8.4	4.5
Potash (K_2O equivalent)			U.S.S.R.	**Canada**	East Germany	West Germany	France
	000 t	28 713	10 000	6 695	3 475	2 580	1 750
	% of world total		34.8	23.3	12.1	9.0	6.1
Nickel (mine production)			U.S.S.R.	**Canada**	Australia	New Caledonia	Indonesia
	000 t	777	175	170	86	62	48
	% of world total		22.5	21.9	11.1	8.0	6.2
Sulphur, elemental			U.S.A.	**Canada**	Poland	U.S.S.R.	Mexico
	000 t	37 727	10 329	8 102	4 876	4 760	1 977
	% of world total		27.4	21.4	12.9	12.6	5.2
Asbestos			U.S.S.R.	**Canada**	South Africa	Zimbabwe	Brazil
	000 t	4 143	2 400	776	165	165	135
	% of world total		57.9	18.7	4.0	4.0	3.3
Gypsum			U.S.A.	**Canada**	Japan	France	Spain
	000 t	81 209	13 359	8 707	6 260	5 443	5 262
	% of world total		16.4	10.7	7.7	6.7	6.5
Titanium concentrates (ilmenite)			Australia	Norway	**Canada**	U.S.S.R.	South Africa
	000 t	4 450	1 269	735	508	444	435
	% of world total		28.5	16.5	11.4	10.0	9.8
Cadmium (refined production)			U.S.S.R.	Japan	**Canada**	U.S.A.	Belgium
	t	19 046	2 750	2 581	1 712	1 678	1 252
	% of world total		14.4	13.6	9.0	8.8	6.6
Aluminum (primary metal)			U.S.A.	U.S.S.R.	**Canada**	Australia	West Germany
	000 t	15 429	3 500	2 300	1 279	852	745
	% of world total		22.7	14.9	8.3	5.5	4.8
Gold (mine production)			South Africa	U.S.S.R.	**Canada**	China	U.S.A.
	t	1 463	669	270	88	65	60
	% of world total		45.7	18.5	6.0	4.4	4.1
Platinum group metals (mine production)			U.S.S.R.	South Africa	**Canada**	Japan	U.S.A.
	kg	228 424	115 100	99 500	10 534	1 720	467
	% of world total		50.4	43.6	4.6	0.8	0.2
Copper (mine production)			Chile	U.S.A.	U.S.S.R.	**Canada**	Zambia
	000 t	8 412	1 356	1 106	1 030	724	520
	% of world total		16.1	13.1	12.2	8.6	6.2
Molybdenum (Mo content)			U.S.A.	Chile	U.S.S.R.	**Canada**	Peru
	t	94 365	46 992	18 415	11 340	7 852	3 810
	% of world total		49.8	19.5	12.0	8.3	4.0
Lead (mine production)			U.S.S.R.	Australia	U.S.A.	**Canada**	Mexico
	000 t	3 561	580	498	424	285	207
	% of world total		16.3	14.0	11.9	8.0	5.8
Cobalt (mine production)			Zaire	Zambia	U.S.S.R.	**Canada**	Australia
	t	31 141	16 329	4 536	2 722	2 067	1 361
	% of world total		52.4	14.5	8.7	6.6	4.4
Silver (mine production)			Mexico	Peru	U.S.S.R.	U.S.A.	**Canada**
	t	13 392	2 153	1 895	1 620	1 224	1 207
	% of world total		16.1	14.2	12.1	9.1	9.0

[1] Total of western world.

P Preliminary.

TABLE 9. CANADA, CENSUS VALUE ADDED, TOTAL ACTIVITY, MINING AND MINERAL MANUFACTURING INDUSTRIES, 1979-85

	1979	1980	1981	1982	1983	1984	1985
				($ million)			
Mining							
Metallic minerals							
Gold	322.8	588.8	519.0	566.2	693.6	660.8	635.3
Silver-lead-zinc	671.9	513.6	380.3	351.1	294.2	465.7	275.3
Nickel-copper-zinc	2 469.7	2 992.2	2 007.9	1 144.9	1 567.3	2 008.1	1 868.5
Iron	1 022.2	1 005.0	1 036.0	761.4	644.6	681.1	817.1
Uranium	525.4	559.3	610.3	600.1	496.9	772.5	813.1
Miscellaneous metal mines	179.7	243.3	150.2	73.7	33.2	72.1	65.4
Total	5 191.6	5 902.2	4 703.8	3 497.4	3 729.8	4 660.5	4 474.7
Industrial minerals							
Asbestos	456.8	473.4	431.5	267.3	254.9	252.7	217.6
Gypsum	27.5	26.9	31.3	26.6	35.1	40.2	50.7
Peat	38.8	42.7	47.8	41.1	43.0	47.1	63.0
Potash	613.5	900.4	889.7	488.5	455.4	717.1	428.8
Sand and gravel	91.5	92.0	98.3	75.6	90.3	104.9	132.9
Stone	121.7	123.4	122.5	109.4	119.5	160.1	207.5
Miscellaneous nonmetals	140.1	152.8	171.0	183.5	201.8	240.5	226.8
Total	1 489.8	1 811.6	1 791.9	1 192.1	1 200.0	1 562.5	1 327.2
Fuels							
Coal	658.6	621.6	671.1	838.0	893.1	1 314.2	1 264.5
Petroleum and natural gas	12 554.1	14 917.3	15 924.6	18 899.8	22 171.3	25 008.4	25 428.7
Total	13 212.7	15 538.9	16 595.8	19 753.5	23 064.3	26 322.6	26 693.2
Total mining industry	19 894.1	23 252.7	23 091.4	24 443.0	27 994.1	32 545.7	32 495.1
Mineral manufacturing							
Primary metal industries							
Primary steel	2 424.3	2 537.9	2 750.9	2 149.9	2 464.9	2 939.6	3 105.9
Steel pipe and tube	280.4	297.6	378.3	320.3	213.4	389.6	388.2
Iron foundries	298.2	266.9	266.0	279.9	326.0	447.7	471.5
Smelting and refining	1 401.0	1 976.9	1 808.9	1 493.0	1 912.4	2 236.9	2 202.4
Aluminum rolling, casting and extruding	249.0	273.5	292.8	289.9	328.2	394.7	284.3
Copper and alloy rolling, casting and extruding	131.5	103.7	129.3	101.6	117.7	147.8	134.7
Metal rolling, casting and extruding, n.e.s.	198.9	203.6	210.4	169.2	234.1	323.1	355.2
Total	4 983.3	5 660.1	5 836.6	4 803.8	5 596.9	6 879.3	7 042.1
Nonmetallic mineral products industries							
Cement manufacturers	388.8	357.3	422.2	387.4	407.5	421.9	490.7
Lime manufacturers	49.3	59.5	62.8	60.1	66.2	75.4	70.1
Concrete products manufacturers	328.7	324.6	378.5	349.7	333.6	376.5	463.9
Ready-mix concrete manufacturers	341.6	352.4	430.1	388.6	405.0	397.5	455.3
Clay products (domestic clay)	87.5	84.6	82.0	57.1	78.2	87.7	92.9
Clay products (imported clay)	44.9	51.6	50.9	37.9	37.2	37.3	41.4
Glass manufacturers	294.9	308.1	364.6	339.6	403.8	460.9	466.4
Glass products manufacturers	141.0	143.6	141.0	144.9	209.8	258.1	320.7
Abrasive manufacturers	79.4	92.1	95.9	80.4	91.4	101.9	97.8
Other nonmetallic mineral products industries	460.0	477.5	483.4	426.7	487.6	571.5	672.5
Total	2 226.2	2 251.3	2 510.5	2 272.4	2 521.4	2 788.4	3 171.8
Petroleum and coal products industries							
Petroleum refining	1 390.9	1 750.1	2 641.5	2 108.4	2 563.7	2 498.2	2 478.8
Manufacturers of lubricating oil and greases	38.3	26.7	35.0	31.7	24.8	56.1	75.7
Other petroleum and coal products industries	30.5	36.0	39.3	39.9	52.6	42.1	41.0
Total	1 459.8	1 812.8	2 715.8	2 180.1	2 641.1	2 596.4	2 595.5
Total mineral manufacturing	8 669.2	9 724.2	11 062.9	9 256.2	10 759.5	12 264.1	12 809.3
Total mining and mineral manufacturing	28 563.3	32 977.0	34 154.3	33 699.3	38 753.6	44 809.8	45 304.5

n.e.s. Not elsewhere specified.

TABLE 10. CANADA, GROSS DOMESTIC PRODUCT OF INDUSTRIAL PRODUCTION, MINING AND MINERAL MANUFACTURING AT FACTOR COST, 1980-86

(1981=100)	1980	1981	1982	1983	1984	1985	1986P
	($ millions)						
Total industrial production	86 879.6	88 675.3	80 910.0	84 981.6	91 963.8	96 502.3	96 894.3
Total mining	19 660.2	17 453.5	16 462.9	17 019.1	18 968.4	19 901.4	19 000.1
Metals							
Gold mines	402.1	487.0	655.7	732.9	797.7	907.1	1 047.0
Iron mines	780.1	820.7	559.5	528.1	637.6	711.1	680.5
Other metal mines	3 383.5	2 514.6	2 134.8	2 229.6	2 545.7	2 495.5	2 607.8
Fuels							
Crude oil and natural gas	11 557.4	9 787.0	9 836.1	10 115.2	10 618.1	11 141.8	10 906.0
Nonmetals							
All nonmetals	741.0	751.3	572.6	630.3	799.2	699.6	715.8
Asbestos	372.5	358.3	248.7	243.3	240.5	244.8	196.4
Salt	67.7	71.0	77.3	81.7	92.9	91.2	98.3
Coal	431.3	466.3	436.9	447.3	656.5	703.2	637.0
Quarry and sand pits	329.1	314.6	230.2	219.4	247.9	220.7	243.6
Services related to mining	1 977.9	1 882.7	1 711.1	1 791.3	2 332.3	2 686.4	1 867.7
Mineral manufacturing							
Primary metals	4 710.5	5 101.0	3 967.1	4 452.1	5 107.2	5 121.5	5 094.7
Primary steel	2 405.1	2 378.2	1 810.2	1 954.6	2 231.9	2 201.5	2 176.8
Steel pipe and tube mills	317.5	322.4	206.1	167.4	238.4	252.2	194.2
Iron foundries	260.8	238.8	230.6	234.2	300.6	297.7	310.8
Nonferrous smelting and refining	1 292.2	1 610.0	1 282.8	1 546.4	1 705.4	1 725.1	1 744.4
Nonmetallic mineral products	2 093.7	2 015.7	1 674.4	1 753.4	1 900.2	2 048.7	2 171.0
Cement	332.2	318.5	254.8	245.9	271.8	302.2	320.5
Concrete products	316.6	311.6	257.4	243.5	278.2	326.1	363.7
Ready-mix concrete	333.2	350.8	276.7	281.7	290.4	326.5	362.7
Glass and glass products	414.2	422.0	397.4	466.7	512.7	528.1	528.1
Miscellaneous nonmetallic products	576.3	505.2	418.4	438.1	466.8	474.4	488.1
Petroleum and coal products	741.2	858.8	732.9	695.6	695.5	679.7	677.2

P Preliminary.

TABLE 11. CANADA, GROSS DOMESTIC PRODUCT BY INDUSTRIES AT FACTOR COST, 1980-86^{r}

(1981=100)	1980	1981	1982	1983	1984	1985	1986P
				($ millions)			
Gross domestic product, all industries	307 388.8	319 537.0	307 521.8	317 201.5	333 274.0	347 708.9	358 938.2
Agriculture	9 736.0	10 611.2	10 933.4	10 610.2	10 810.8	10 703.4	11 579.1
Forestry	2 094.4	2 045.0	1 849.1	2 352.5	2 078.4	2 119.4	2 366.2
Fishing and trapping	493.1	565.3	547.2	541.3	468.5	539.2	541.1
Mines (including milling), quarries and oil wells	19 660.2	17 453.4	16 462.9	17 019.1	18 968.4	19 901.4	19 000.1
Electric power, gas and water utilities	8 781.7	8 950.3	8 976.8	9 376.0	10 151.1	10 765.4	10 973.0
Manufacturing	59 460.7	61 648.1	54 844.3	57 954.5	62 200.3	65 190.5	66 255.8
Construction	22 526.9	25 095.1	23 051.3	23 367.7	23 043.0	24 053.6	24 628.5
Transportation and storage	14 600.3	14 428.6	13 222.0	13 928.4	15 117.4	15 814.4	16 183.4
Communications	8 094.3	8 728.3	8 821.5	8 979.7	9 288.6	9 715.9	10 338.4
Trade, wholesale	14 425.6	15 413.6	13 590.9	14 326.4	15 440.6	16 331.3	17 652.7
Trade, retail	19 531.1	19 661.3	18 860.4	19 731.6	20 800.3	22 388.0	23 238.7
Community, business and personnel services	30 428.2	32 911.3	32 644.3	32 487.6	35 017.1	36 468.7	39 079.0
Finance, insurance and real estate	43 050.1	44 155.3	44 690.3	46 177.7	48 698.7	51 447.5	53 390.3
Government service	21 146.0	21 714.9	22 349.1	22 678.4	22 933.4	23 109.6	23 264.1

P Preliminary, ^{r} Revised.

TABLE 12. CANADA, GROSS DOMESTIC PRODUCT FOR SELECTED INDUSTRIES BY PROVINCE, 1984

	Nfld.	Prince Edward Island	Nova Scotia	New Brunswick	Quebec	Ontario	Manitoba	Sask.	Alberta	British Columbia	Yukon and N.W.T.	Canada
						($ million)						
Agriculture	20.5	121.5	140.5	124.4	1 721.4	2 915.7	962.7	1 742.0	1 755.4	601.5	-	10 105.6
Forestry	54.7	0.3	41.3	200.8	404.0	458.6	20.6	23.7	35.3	1 264.9	-	2 504.1
Fishing, hunting and trapping	99.9	23.4	159.5	46.5	38.7	29.3	13.3	4.8	4.2	149.9	2.9	572.6
Mining[1]	484.3	0.1	260.8	191.4	779.0	2 211.4	424.1	2 437.6	16 555.4	1 701.2	492.0	25 537.4
Manufacturing	483.1	83.4	1 336.7	982.0	19 914.4	41 103.9	1 821.4	785.6	3 668.2	6 106.5	16.7	76 300.7
Construction	484.2	93.1	750.7	573.9	5 509.8	7 912.4	825.1	1 125.5	3 711.1	3 092.6	238.0	24 316.0
Electric power, gas and water utilities	341.0	19.6	293.0	442.6	4 126.3	4 658.4	568.9	413.6	1 467.2	1 452.4	55.0	13 838.2
Goods-producing industries	1 967.7	341.4	2 982.5	2 562.4	32 493.6	59 289.7	4 636.1	6 530.8	27 196.8	14 369.0	804.6	153 174.6

[1] Cement, lime, clay and clay products (domestic clays) industries are included under "manufacturing".
- Nil.

TABLE 13. CANADA, GROSS DOMESTIC PRODUCT FOR MINING BY PROVINCE, 1978-84

	Nfld.	Prince Edward Island	Nova Scotia	New Brunswick	Quebec	Ontario	Manitoba	Sask.	Alberta	British Columbia	Yukon and N.W.T.	Canada
						($ million)						
1978	249.2	0.1	83.1	113.7	774.5	1 255.8	190.5	855.7	5 191.2	962.8	294.6	9 950.9
1979	475.6	0.1	102.4	206.4	989.5	1 600.8	354.5	1 014.2	7 409.6	1 621.4	440.4	14 214.8
1980	445.1	0.1	116.1	96.2	1 223.1	2 476.9	428.6	1 304.4	10 033.1	1 479.5	516.7	18 119.5
1981	471.8	0.1	124.9	125.9	1 099.6	1 885.6	290.3	1 298.5	10 593.0	1 264.6	358.4	17 510.6
1982	313.0	0.1	190.0	124.5	866.5	1 356.1	282.2	1 296.3	12 531.2	1 209.7	412.8	18 580.3
1983	367.8	0.1	277.4	94.2	853.6	1 689.4	352.6	1 640.9	14 648.1	1 319.5	443.9	21 687.6
1984	484.3	0.1	260.8	191.4	779.0	2 211.4	424.1	2 437.6	16 555.4	1 701.2	492.0	25 537.4

TABLE 14. CANADA, GROSS DOMESTIC PRODUCT FOR MINERAL MANUFACTURING BY PROVINCE, 1984

	Primary Metal Fabrication	Nonmetallic Mineral Products Manufacturing	Petroleum and Coal Products Manufacturing	Mineral Manufacturing
		($ millions)		
Newfoundland	x	x	x	x
Prince Edward Island	-	x	-	x
Nova Scotia	x	x	x	x
New Brunswick	x	x	x	x
Quebec	1 731.0	x	494.5	x
Ontario	3 365.2	1 190.0	643.6	5 198.8
Manitoba	117.5	54.8	x	x
Saskatchewan	x	44.8	x	x
Alberta	293.7	207.7	265.6	767.0
British Columbia	406.2	197.9	183.9	788.0
Yukon and Northwest Territories	-	-	x	x
Canada	6 005.4	2 289.7	1 801.2	10 096.3

x Confidential included in total; - Nil.

TABLE 15. CANADA, VALUE OF MINERAL EXPORTS, 1980-86

	1980	1981	1982	1983	1984	1985	1986P
				($ million)			
Ferrous							
Crude material	1 343.0	1 540.7	1 103.7	1 053.4	1 207.0	1 291.9	1 215.0
Smelted and refined material	284.8	475.1	232.6	300.3	247.8	242.1	278.0
Semi-Fabricated material	1 789.7	1 874.8	1 763.7	1 360.7	2 007.0	2 158.2	2 164.9
Total	3 417.5	3 890.5	3 100.1	2 714.4	3 461.8	3 692.2	3 657.9
Nonferrous							
Crude material	2 029.2	1 707.0	1 346.7	1 323.3	1 462.2	1 334.9	1 515.5
Smelted and refined material	6 372.2	5 836.5	4 982.1	5 620.4	6 630.7	6 278.5	7 566.8
Semi-Fabricated material	622.1	586.9	544.1	638.1	873.6	798.4	865.3
Total	9 023.5	8 130.4	6 872.9	7 581.8	8 966.5	8 411.9	9 947.7
Nonmetals							
Crude material	2 369.5	2 682.2	2 202.2	2 217.1	2 882.7	3 084.3	2 833.7
Smelted and refined material	-	-	-	-	-	-	-
Semi-Fabricated material	662.7	711.2	664.2	657.2	891.7	916.1	978.7
Total	3 032.2	3 393.4	2 866.4	2 874.3	3 774.4	4 000.4	3 812.4
Mineral fuels							
Crude material	8 055.5	8 201.3	9 111.0	8 679.4	10 507.4	12 236.6	8 274.7
Smelted and refined material	2 596.0	2 800.2	2 364.1	2 717.0	3 252.0	3 445.8	2 589.1
Semi-Fabricated material	353.6	512.9	607.8	466.1	485.2	485.5	182.9
Total	11 005.1	11 514.4	12 083.0	11 862.6	14 244.6	16 167.8	11 046.7
Total minerals and products							
Crude material	13 797.1	14 131.2	13 763.6	13 273.3	16 059.4	17 947.7	13 838.9
Smelted and refined material	9 253.1	9 111.8	7 578.8	8 637.7	10 130.5	9 966.4	10 433.9
Semi-Fabricated material	3 428.1	3 685.8	3 579.9	3 122.1	4 257.6	4 358.2	4 191.8
Total	26 478.3	26 928.8	24 922.3	25 033.0	30 447.5	32 272.3	28 464.6

P Preliminary; - Nil.

TABLE 16. CANADA, VALUE OF MINERAL IMPORTS, 1980-86

	1980	1981	1982	1983	1984	1985	1986P
				($ million)			
Ferrous							
Crude material	356.1	373.2	227.3	285.2	398.9	427.0	360.6
Smelted and refined material	153.0	205.2	86.2	93.9	174.0	162.7	212.0
Semi-Fabricated material	1 308.0	2 127.0	1 193.2	1 114.8	1 502.6	1 885.0	1 672.3
Total	1 817.1	2 705.4	1 506.7	1 493.8	2 075.5	2 474.7	2 244.9
Nonferrous							
Crude material	1 553.3	1 219.3	1 001.7	1 125.8	1 132.3	909.0	1 236.7
Smelted and refined material	2 310.6	1 910.7	1 441.2	1 835.8	1 882.5	2 247.1	2 672.8
Semi-Fabricated material	620.7	701.6	525.6	603.4	900.7	836.6	960.6
Total	4 484.6	3 831.5	2 968.4	3 565.0	3 915.5	4 019.7	4 870.1
Nonmetals							
Crude material	337.7	349.2	290.3	277.8	334.3	344.2	356.1
Smelted and refined material	-	-	-	-	-	-	-
Semi-Fabricated material	874.9	1 008.2	837.8	958.5	1 121.7	1 304.1	1 382.5
Total	1 212.6	1 357.4	1 128.1	1 236.3	1 456.0	1 648.3	1 738.6
Mineral fuels							
Crude material	7 737.4	8 839.7	5 912.6	4 162.0	4 470.8	4 584.3	3 631.1
Smelted and refined material	564.6	713.6	683.5	862.7	1 445.4	1 418.0	1 327.9
Semi-Fabricated material	176.7	228.1	210.2	227.9	326.7	420.0	403.3
Total	8 478.7	9 781.4	6 806.3	5 252.6	6 242.9	6 422.2	5 362.3
Total minerals and products							
Crude material	9 984.6	10 781.4	7 431.8	5 850.8	6 336.2	6 264.5	5 584.5
Smelted and refined material	3 028.2	2 829.5	2 210.8	2 792.4	3 501.9	3 827.8	4 212.7
Semi-Fabricated material	2 980.4	4 064.9	2 766.9	2 904.6	3 851.7	4 472.6	4 418.7
Total	15 993.2	17 675.7	12 409.5	11 547.8	13 689.8	14 564.9	14 215.9

P Preliminary; - Nil.

TABLE 17. CANADA, VALUE OF MINERAL EXPORTS IN RELATION TO TOTAL DOMESTIC EXPORT TRADE, 1976 1981 AND 1986

	1976		1981		1986P	
	($ million)	(%)	($ million)	(%)	($ million)	(%)
Crude material	7 495.7	20.1	14 131.2	17.4	13 838.9	11.9
Smelted and refined material	3 498.5	9.4	9 111.8	11.2	10 433.9	9.0
Semi-Fabricated material	1 357.8	3.6	3 685.8	4.5	4 191.8	3.6
Total	12 352.0	33.2	26 928.8	33.1	28 464.6	24.4
Total exports, all products	37 258.8	100.0	81 336.7	100.0	116 561.7	100.0

P Preliminary.

TABLE 18. CANADA, VALUE OF MINERAL IMPORTS IN RELATION TO TOTAL IMPORT TRADE, 1976, 1981 AND 1986

	1976		1981		1986P	
	($ million)	(%)	($ million)	(%)	($ million)	(%)
Crude material	4 303.1	11.8	10 781.4	14.0	5 584.5	5.0
Smelted and refined material	656.2	1.8	2 829.5	3.7	4 212.7	3.8
Semi-Fabricated material	1 516.8	4.1	4 064.9	5.3	4 418.7	4.0
Total	6 476.1	17.7	17 675.8	22.9	14 215.9	12.7
Total imports, all products	36 607.5	100.0	77 139.9	100.0	111 516.3	100.0

P Preliminary.

TABLE 19. CANADA, VALUE OF MINERAL EXPORTS BY MAIN GROUPS AND DESTINATION, 1986P

	United States	United Kingdom	EFTA[1]	EEC[2]	Japan	Other Countries	Total
				($ million)			
Ferrous materials and products	2 726.4	185.7	10.3	459.3	62.1	214.1	3 657.9
Nonferrous materials and products	6 827.5	652.4	329.7	589.7	902.9	645.4	9 947.7
Nonmetallic mineral materials and products	1 760.0	33.0	15.4	422.6	127.0	1 454.4	3 812.3
Mineral fuels, materials and products	8 801.2	67.8	29.0	338.7	1 338.4	471.6	11 046.7
Total	20 115.1	938.9	384.4	1 810.3	2 430.4	2 785.5	28 464.6
Percentage of total mineral exports	70.7	3.3	1.4	6.4	8.5	9.8	100.0

[1] European Free Trade Association includes Austria, Norway, Portugal, Sweden, Switzerland, Finland and Iceland. [2] European Economic Community includes Belgium-Luxembourg, France, Italy, Netherlands, West Germany, Greece, Denmark and Ireland.
P Preliminary.

TABLE 20. CANADA, VALUE OF MINERAL IMPORTS BY MAIN GROUPS AND ORIGIN, 1986P

	United States	United Kingdom	EFTA[1]	EEC[2]	Japan	Other Countries	Total
				($ million)			
Ferrous materials and products	1 124.8	128.1	78.5	432.5	193.4	287.7	2 245.0
Nonferrous materials and products	3 748.1	60.1	41.9	193.2	85.0	741.8	4 870.1
Nonmetallic mineral materials and products	1 193.8	36.7	25.0	291.6	56.6	134.9	1 738.5
Mineral fuels, materials and products	2 094.1	1 361.0	67.3	193.6	5.1	1 641.1	5 362.3
Total	8 160.9	1 585.9	212.6	1 110.9	340.0	2 805.5	14 215.9
Percentage of total mineral imports	57.4	11.2	1.5	7.8	2.4	19.7	100.0

[1] European Free Trade Association includes Austria, Norway, Portugal, Sweden, Switzerland, Finland and Iceland. [2] European Economic Community includes Belgium-Luxembourg, France, Italy, Netherlands, West Germany, Greece, Denmark and Ireland.
P Preliminary.

TABLE 21. CANADA, VALUE OF MINERAL EXPORTS, BY COMMODITY AND DESTINATION, 1986P

	United States	United Kingdom	EFTA[1]	EEC[2]	Japan	Other Countries	Total
				($000)			
Petroleum	5 038 290	20 462	1 907	14 074	19 719	73 138	5 167 589
Iron and steel	2 684 272	185 658	10 337	459 342	53 998	212 808	3 606 417
Natural gas	3 165 977	-	-	-	-	2 757	3 168 733
Gold	2 632 890	1 767	17 565	26 728	166 707	16 913	2 862 568
Aluminum	1 956 458	8 108	39 396	42 144	175 458	295 737	2 517 303
Coal	31 828	21 387	19 340	97 762	1 312 057	386 585	1 868 958
Nickel	400 060	218 061	185 140	123 436	28 241	78 484	1 033 422
Copper	569 981	108 726	52 066	109 170	367 846	115 922	1 323 711
Sulphur	95 180	20	-	128 933	17	910 122	1 134 273
Uranium	565 127	25 949	7 752	226 846	6 624	9 131	841 430
Potash	425 620	3 350	993	40 665	56 220	301 399	828 247
Zinc	366 192	43 045	7 393	141 858	35 568	83 194	677 248
Asbestos	50 016	17 191	11 048	104 604	50 233	179 433	412 525
Silver	329 640	752	150	5 384	45 072	5 094	386 092
All other minerals	1 803 553	284 412	31 354	289 369	112 650	114 835	2 636 124
Total	20 115 084	938 888	384 441	1 810 315	2 430 410	2 785 552	28 464 640

[1] European Free Trade Association includes Austria, Norway, Portugal, Sweden, Switzerland, Finland and Iceland. [2] European Economic Community includes Belgium-Luxembourg, France, Italy, Netherlands, West Germany, Greece, Denmark and Ireland.
P Preliminary; - Nil.

TABLE 22. CANADA, VALUE OF MINERAL IMPORTS, BY COMMODITY AND ORIGIN, 1986P

	United States	United Kingdom	EFTA[1]	EEC[2]	Japan	Other Countries	Total
				($000)			
Petroleum	1 230 135	1 360 979	67 263	190 554	5 069	1 635 752	4 489 756
Iron and steel	1 087 091	125 994	70 980	425 528	193 404	264 208	2 167 216
Gold	1 712 662	167	6 494	1 944	-	42 888	1 764 156
Aluminum	758 797	10 940	7 051	85 580	70 465	352 074	1 285 179
Coal	834 955	28	-	2 716	28	4 868	842 595
Platinum Group Metals	659 020	18 336	74	3 610	-	45 698	726 740
Copper	259 469	3 018	5 953	23 840	9 318	87 600	389 192
Clays	231 646	7 446	3 409	85 819	21 260	8 864	358 402
Phosphatic materials	251 216	214	54	3 547	-	5 382	260 414
Nickel	61 446	15 896	16 088	9 067	455	44 947	147 902
Abrasives	104 020	2 567	8 724	24 107	2 843	3 933	146 193
Graphite	73 757	501	1 388	9 092	8 790	499	94 027
Stone, building	25 731	95	762	32 613	15	5 437	64 653
Mineral pigments	32 410	1 915	145	13 514	-	4 028	52 011
All other minerals	838 534	37 853	24 234	199 055	28 388	299 377	1 427 443
Total	8 160 889	1 585 949	212 619	1 110 856	340 035	2 805 515	14 215 879

[1] European Free Trade Association includes Austria, Norway, Portugal, Sweden, Switzerland, Finland and Iceland. [2] European Economic Community includes Belgium-Luxembourg, France, Italy, Netherlands, West Germany, Greece, Denmark and Ireland.
P Preliminary; - Nil.

TABLE 23. CANADA, PHYSICAL VOLUME OF IMPORT TRADE FOR SELECTED COMMODITIES, 1980-86

	Units of Weight	1980	1981	1982	1983	1984	1985	1986P
Crude materials								
Metals								
Iron ore	t	5 875 347	5 794 713	3 359 304	4 013 119	4 946 916	5 800 222	5 367 244
Bauxite ore	t	3 504 371	2 734 665	2 574 719	2 329 911	2 451 541	2 074 206	2 112 905
Alumina	t	983 972	1 020 550	939 268	1 063 176	1 349 213	1 544 007	1 724 599
Manganese ore	t	95 161	119 746	71 655	42 261	77 546	102 202	94 916
Nonmetals								
Phosphate rock	t	3 816 514	3 245 446	2 477 199	2 625 390	3 142 654	2 621 668	2 387 755
Limestone, crushed	t	2 418 331	2 526 876	1 485 428	1 799 859	1 944 045	2 071 651	2 354 276
Salt & brine	t	1 151 204	1 254 992	1 526 880	777 311	1 053 210	1 255 510	1 328 300
Silica sand	t	1 200 236	1 142 880	788 768	982 664	1 076 083	983 340	1 055 215
Sand & gravel	t	1 209 583	1 446 872	1 179 284	878 613	1 266 983	1 111 801	1 047 189
Clay, ground & unground	t	403 281	413 038	345 384	368 996	403 481	461 755	527 371
Bentonite	t	471 683	311 249	238 027	187 229	377 054	346 018	326 298
Fluorspar	t	223 940	173 598	126 594	141 928	166 710	111 726	164 114
Fuels								
Coal	t	16 066 492	14 993 112	15 715 860	14 822 356	19 060 700	15 024 782	13 368 536
Petroleum, crude	m^3	32 733 819	30 751 766	19 670 772	14 603 437	14 849 581	15 845 864	20 153 969
Fabricated materials								
Metals								
Steel								
sheets & strips	t	582 263	1 733 683	540 408	536 819	699 381	1 069 154	914 793
bars & rods	t	189 982	340 775	219 629	277 287	405 194	363 979	408 038
pipes & tubes	t	322 123	364 979	249 661	217 054	315 817	455 375	254 155
structural shapes	t	209 811	364 384	120 369	162 133	234 614	232 619	209 421
castings & forgings	t	129 360	118 491	70 130	92 522	135 892	113 200	101 736
Aluminum sheets, rods, n.e.s.	t	114 197	122 164	99 550	120 384	185 199	175 461	179 229
Ferroalloys	t	118 516	117 911	64 662	71 560	106 568	124 770	93 999
Nonmetals								
Cement	t	223 249	721 206	231 829	238 268	236 230	372 800	490 133
Phosphate fertilizers	t	248 329	307 217	249 827	360 302	333 765	580 135	429 547
Fire bricks	t	236 202	187 020	132 601	154 765	177 126	167 202	154 295
Fuels								
Fuel oil	000 L	1 617 606	1 256 790	1 571 003	1 446 255	2 399 279	2 073 480	1 716 027
Coke, petroleum	t	908 322	935 929	650 813	768 981	886 734	874 331	910 602
Coke, nes	t	403 377	500 146	400 506	585 859	660 258	783 718	881 086

P Preliminary; n.e.s. Not elsewhere specified.

TABLE 24. CANADA, PHYSICAL VOLUME OF EXPORT TRADE FOR SELECTED COMMODITIES, 1980-86

	Unit of Weight	1980	1981	1982	1983	1984^{r}	1985	1986^{p}
Crude material								
Metals								
Iron, ores	t	39 020 924	41 452 042	27 281 399	25 527 964	30 737 466	32 259 296	31 008 408
Zinc, ores & concentrates	t	435 833	516 214	457 753	626 174	550 213	396 103	433 209
Copper, ores & concentrates	t	286 076	276 810	257 930	313 798	332 373	320 619	340 027
Lead, ores & concentrates	t	147 006	146 304	106 744	85 458	114 720	93 657	112 918
Nonmetals								
Potash	t	10 554 063	10 067 830	7 221 375	9 411 895	11 493 732	9 980 965	9 893 879
Sulphur, crude	t	6 850 142	7 309 215	6 111 447	5 670 281	7 326 852	7 818 425	6 257 074
Gypsum	t	4 960 239	5 094 872	4 775 780	5 187 032	6 224 573	5 879 664	5 885 349
Salt and brine	t	1 655 770	1 507 708	1 721 892	1 914 626	2 545 011	2 263 076	2 502 526
Limestone, crushed	t	2 214 489	1 758 298	1 517 498	1 390 795	1 216 674	1 195 939	1 350 351
Asbestos, crude & fibers	t	1 217 733	1 062 287	880 703	753 901	796 764	722 003	752 068
Crude refractory materials	t	803 893	629 770	40 838	241 131	579 487	534 579	728 659
Nepheline syenite	t	448 465	476 280	414 781	398 295	387 066	351 026	338 263
Sand and gravel	t	383 531	318 634	168 691	95 634	109 809	241 790	249 835
Fuels								
Coal	t	14 310 781	16 285 101	15 528 538	16 974 344	24 354 894	27 591 749	25 899 820
Natural gas	000 m^3	22 963 134	21 689 360	22 072 136	19 296 956	21 427 034	26 154 592	20 872 994
Semi-Fabricated materials								
Metals								
Aluminum, pig ingots	t	784 732	725 442	896 370	925 398	833 631	1 050 789	1 163 685
Iron, pig ingots	t	562 351	466 358	485 621	348 280	392 135	574 111	519 562
Zinc, pig ingots	t	472 143	453 464	470 396	500 454	529 653	555 621	427 175
Copper, refinery shapes	t	336 198	263 045	232 625	298 527	345 985	280 033	304 883
Lead, pig ingots	t	126 540	119 814	146 127	147 270	124 149	113 993	111 831
Nonmetals								
Cement	t	1 550 561	1 578 658	1 752 113	1 512 563	2 130 111	2 485 699	2 612 606
Peat	t	390 458	326 826	356 027	396 879	460 600	446 521	534 987
Lime, quick & hydrated	t	403 166	432 845	281 248	215 945	186 746	194 097	189 509
Fuels								
Fuel oil	000 L	4 273 512	3 846 906	2 721 922	3 825 520	4 424 697	4 667 298	4 731 263
Butane gas, liquified	000 L	2 563 406	3 137 545	3 572 546	3 011 824	3 278 444	3 098 985	2 947 776
Propane gas, liquified	000 L	3 879 915	3 867 950	4 513 705	3 534 575	3 887 986	3 172 345	2 697 959
Gasoline	000 L	706 539	600 969	536 268	1 240 028	1 583 578	2 382 777	2 045 995
Coke, n.e.s.	t	319 555	192 515	129 793	45 607	116 225	169 069	108 788

^{p} Preliminary; ^{r} Revised; n.e.s. Not elsewhere specified.

TABLE 25. CANADA, MAJOR MINERAL EXPORT DESTINATIONS BY CLASS OF PRODUCT, VALUE AND PERCENTAGE, 1986

	Crude		Smelted and Refined		Semi-Fabricated		Total	
	Value	Percentage	Value	Percentage	Value	Percentage	Value	Percentage
	($ millions)	(%)	($ millions)	(%)	($ millions)	(%)	($ millions)	(%)
United States	8 157.1	58.9	8 243.0	79.0	3 715.0	88.6	20 115.1	70.7
Japan	2 082.8	15.1	307.9	4.1	39.8	0.9	2 430.4	8.5
United Kingdom	417.7	3.0	418.9	4.0	102.3	2.4	938.9	3.3
Korea, South	406.4	2.9	70.1	0.7	5.5	0.1	481.9	1.7
France	257.1	1.9	159.7	1.5	5.7	0.1	422.5	1.5
Belgium-Luxembourg	258.1	1.9	112.3	1.1	11.6	0.3	382.0	1.3
Germany, West	253.8	1.8	85.8	0.8	19.4	0.5	358.9	1.3
Netherlands	201.4	1.5	133.8	1.3	9.0	0.2	344.2	1.2
Brazil	251.3	1.8	3.2	x	3.3	0.1	257.8	0.9
Taiwan	112.7	0.8	69.1	0.7	43.4	1.0	225.2	0.8
Norway	25.8	0.2	197.3	1.8	1.0	x	224.1	0.8
Italy	138.5	1.0	44.5	0.5	14.3	0.3	197.3	0.7
U.S.S.R.	175.2	1.3	-	-	0.5	x	175.7	0.6
Morocco	141.5	1.0	-	-	x	x	141.5	0.5
Australia	113.9	0.8	9.9	0.1	13.5	0.3	137.2	0.5
China	37.8	0.3	91.3	0.9	5.8	0.1	135.0	0.5
India	110.0	0.8	3.3	x	6.8	0.2	120.2	0.4
Mexico	48.3	0.3	3.2	x	52.1	1.2	103.7	0.4
Sweden	24.2	0.2	55.5	0.5	3.6	0.1	83.3	0.3
Indonesia	55.0	0.4	9.5	0.1	12.1	0.3	76.6	0.3
Hong Kong	18.8	0.1	47.0	0.5	9.0	0.2	74.7	0.3
South Africa	64.7	0.5	0.9	x	2.9	0.1	68.5	0.2
Tunisia	62.2	0.4	2.8	x	0.4	x	65.3	0.2
Israel	27.0	0.2	21.6	0.2	3.0	0.1	51.5	0.2
Other Countries	336.6	2.4	346.5	3.3	112.2	2.7	8 531.4	3.0
Total	12 838.9	100.0	10 433.9	100.0	4 191.8	100.0	28 464.6	100.0

- Nil; x Too small to be expressed.

TABLE 26. CANADA, MAJOR MINERAL IMPORT ORIGINS BY CLASS, VALUE AND PERCENTAGE, 1986

	Crude		Smelted and Refined		Semi-Fabricated		Total	
	Value ($ millions)	Percentage (%)	Value ($ millions)	Percentage (%)	Value ($ millions)	Percentage (%)	Value ($ millions)	Percentage (%)
United States	2 445.7	43.8	3 033.7	72.0	2 681.4	60.6	8 160.9	57.4
United Kingdom	1 347.2	24.1	68.2	1.6	170.5	3.9	1 586.0	11.2
Venezuela	311.0	5.6	159.2	3.7	33.0	0.7	503.2	3.5
Nigeria	367.0	6.6	-	-	-	-	367.0	2.6
Japan	0.5	x	63.5	1.5	276.0	6.2	340.0	2.4
Germany, West	5.6	0.1	75.2	1.8	193.1	4.4	273.9	1.9
France	8.5	0.2	40.4	1.0	152.7	3.5	201.5	1.4
Mexico	175.9	3.1	5.0	0.1	17.7	0.4	198.5	1.4
Brazil	68.1	1.2	57.4	1.4	72.8	1.6	198.3	1.4
Iran	192.6	3.4	-	-	-	-	192.6	1.4
Belgium-Luxembourg	1.4	x	21.4	0.5	163.5	3.7	186.3	1.3
Saudi Arabia	184.1	3.3	-	-	-	-	184.1	1.3
Australia	68.2	1.2	101.5	2.4	9.7	0.2	179.4	1.3
Italy	4.3	0.1	46.5	1.1	120.1	2.7	170.8	1.2
Spain	93.2	0.2	35.2	0.8	98.0	2.2	142.5	1.0
Jamaica	0.1	x	124.4	3.0	x	x	124.6	0.9
South Africa	54.7	1.0	35.5	0.8	22.0	0.5	112.2	0.8
Netherlands	0.7	x	46.9	1.1	47.3	1.1	95.0	0.7
Norway	55.4	1.0	19.0	0.5	9.2	0.2	83.6	0.6
Korea, South	-	-	0.1	x	75.7	1.7	75.9	0.5
Sweden	0.2	x	1.2	x	63.9	1.4	65.3	0.5
Israel	x	x	13.6	0.3	45.9	1.0	59.5	0.4
Chile	43.8	0.8	1.5	x	3.3	0.1	48.6	0.3
Trinidad and Tobago	2.0	x	22.5	0.5	14.2	0.3	38.6	0.3
Other Countries	238.3	4.3	240.6	5.7	148.7	3.4	627.7	4.4
Total	5 584.5	100.0	4 212.7	100.0	4 418.7	100.0	14 215.9	100.0

- Nil; x Too small to be expressed.

TABLE 27. CANADA, APPARENT CONSUMPTION[1] OF SOME MINERALS AND RELATION TO PRODUCTION[2], 1984-86

	1984			1985			1986p		
	Apparent Consumption	Production	Consumption as % of Production	Apparent Consumption	Production	Consumption as % of Production	Apparent Consumption	Production	Consumption as % of Production
	(tonnes)			(tonnes)			(tonnes)		
Quartz silica	3 629 873	2 658 932	136.5	3 550 246	2 668 650	133.0	3 416 371	2 436 513	140.2
Lime	2 087 216	2 249 114	92.8	2 040 959	2 232 000	92.3	2 221 411	2 364 000	94.0
Salt	8 743 598	10 235 399	85.4	9 077 131	10 084 697	90.0	9 914 299	11 088 524	89.4
Cement	7 346 376	9 240 257	79.5	8 079 101	10 192 000	79.3	7 935 527	10 058 000	78.9
Iron ore	14 538 261	39 929 907	36.4	13 346 387	39 501 601	33.8	10 806 800	36 095 571	29.9
Gypsum	1 682 318	7 775 082	21.6	2 688 932	8 446 794	31.8	2 878 236	8 541 941	33.7
Asbestos	40 216	836 654	4.8	28 561	750 190	3.8	111 771	640 000	17.5

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[1] "Apparent consumption" is production, plus imports, less exports. [2] "Production" refers to producers' shipments.
p Preliminary.

TABLE 28. CANADA, REPORTED CONSUMPTION OF MINERALS AND RELATION TO PRODUCTION, 1983-85

	Unit of Measure	1983			1984			1985p		
		Consumption	Production	Consumption as % of Production	Consumption	Production	Consumption as % of Production	Consumption	Production	Consumption as % of Production
Metals										
Aluminum	t	532 589r	1 091 211	30.5	379 269	1 221 985	31.0	346 033	1 282 316	27.0
Antimony	kg	217 552	385 558	56.4	356 272	553 875	64.3	195 293	1 075 627	18.2
Bismuth	kg	7 241	253 023	2.9	9 398	166 177	5.7	7 284	201 489	3.6
Cadmium	kg	32 885	1 193 379	2.8	28 810	1 605 286	1.8	34 937	1 716 731	2.0
Chromium (chromite)	t	15 682	-	..	21 099	-	..	17 555	-	..
Cobalt	kg	100 996	1 409 626	7.2	112 972	2 123 333	5.3	101 167	2 066 815	4.9
Copper[1]	t	170 443	653 060	26.1	205 476	721 826	28.5	203 335	738 637	27.5
Lead[2]	t	88 579r	271 961	32.6	112 266	264 301	42.5	102 256	268 292	38.1
Magnesium	t	5 568	..	..	6 866	..	..	6 582	..	..
Manganese ore	t	96 697	-	..	109 115	-	..	160 241	-	..
Mercury	kg	37 192	-	..	42 013	-	..	41 462	-	..
Molybdenum (Mo content)	t	410r	10 196	4.0	737	11 557	6.4	772	7 852	9.8
Nickel	t	5 010	125 022	4.0	7 290	173 725	4.2	5 950	169 971	3.5
Selenium	kg	11 706	265 672	4.4	9 845	463 188	2.1	13 960	360 641	3.9
Silver	kg	283 349	1 197 031	23.6	299 440	1 326 720	22.6	217 613	1 197 072	18.2
Tellurium	kg	..	16 391	..	..	18 964	..	..	19 470	..
Tin	t	3 371r	140	2 407.9	4 076	209	1 950.2	3 908	120	3 256.7
Tungsten (W content)	kg	503 651	1 125 558	44.7	659 665	4 195 785	15.7	707 271	4 030 574	17.5
Zinc	t	116 257	987 713	11.8	119 573	1 062 701	11.3	123 256	1 049 275	11.7
Nonmetals										
Barite	t	66 086	45 465	145.4	71 802	64 197	111.8	59 528	71 049	83.8
Feldspar	t	2 213	-	..	2 106	-	..	2 014	-	..
Fluorspar	t	163 404r	-	..	176 852	-	..	151 755	-	..
Mica	kg	3 002	..	..	2 474	..	..	3 105	..	..
Nepheline syenite	t	96 634	523 249	18.1	91 555	520 640	17.6	81 530	467 186	17.5
Phosphate rock	t	2 922 484	-	..	3 267 428	-	..	2 738 387	-	..
Potash (K_2O)	t	229 093	6 293 747	3.6	213 896	7 527 347	2.8	296 810	6 661 077	4.5
Sodium sulphate	t	190 625	453 939	42.0	235 504	389 086	60.5	241 143	366 217	65.8
Sulphur	t	1 089 230	7 309 409	14.9	1 169 849	9 197 254	12.7	1 107 072	8 924 522	12.4
Talc, etc.	t	39 497	97 030	40.7	59 189	122 992	48.1	64 774	126 860	51.1
Fuels										
Coal	000 t	41 588	44 787	92.9	50 364	57 402	87.7	48 018	60 737	79.1
Natural gas[3]	million m^3	43 832	72 229	60.7	47 574	76 053	62.6	50 164	82 218	61.0
Crude oil[4]	000 m^3	81 706	78 751	103.8	82 552	83 532	98.8	79 808	85 400	93.5

Note: Unless otherwise stated, consumption refers to reported consumption of refined metals or nonmetallic minerals by consumers. Production of metals, in most cases, refers to production in all forms, and includes the recoverable content of ores, concentrates, matte, etc., and metal content of primary products recoverable at domestic smelters and refineries. Production of nonmetals refers to producers' shipments. For fuels, production is equivalent to actual output less waste.

[1] Consumption defined as producers' domestic shipments of refined metal. [2] Consumption includes primary and secondary refined metal. [3] Consumption defined as domestic sales. [4] Consumption defined as refinery receipts.

p Preliminary; r Revised; - Nil; .. Not available or not applicable.

TABLE 29. CANADA, DOMESTIC CONSUMPTION OF PRINCIPAL REFINED METALS IN RELATION TO REFINERY PRODUCTION[1], 1979-85

	Unit of Measure	1979	1980	1981	1982	1983	1984	1985P
Zinc								
Domestic consumption[3]	t	131 317	116 618	113 061	100 233	116 257	119 573	123 256
Production	t	580 449	591 565	618 650	511 870	617 033	682 976	692 406
Consumption of production	%	22.6	19.7	18.3	19.6	26.9	17.5	17.8
Aluminum								
Domestic consumption[4]	t	398 834	329 400	336 989	273 523	332 389r	379 249	346 033
Production	t	860 287	1 068 197	1 115 691	1 064 795	1 091 213	1 221 985	1 282 316
Consumption of production	%	46.4	30.8	30.2	25.7	30.5	31.0	27.0
Copper								
Domestic consumption[2]	t	210 689	195 124	216 759	130 559	170 443	205 476	203 335
Production	t	397 263	505 238	476 655	337 780	464 333	504 262	499 626
Consumption of production	%	53.0	38.6	45.5	38.6	36.7	40.7	40.7
Lead								
Domestic consumption[3]	t	98 018	106 836	110 931	103 056	88 579r	112 266	102 254
Production	t	183 769	162 463	168 450	174 310	178 043	174 987	173 220
Consumption of production	%	53.3	65.8	65.9	59.1	49.7	64.2	59.4

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[1] Production of refined metal from all sources, including metal derived from secondary materials at primary refineries.
[2] Producers' domestic shipments of refined metal. [3] Consumption of primary and secondary refined metal, reported by consumers. [4] Consumption of primary refined metal, reported by consumers.
P Preliminary; r Revised.

TABLE 30. AVERAGE ANNUAL PRICES[1] OF SELECTED MINERALS, 1980-86[2]

	Unit of Measure	1980	1981	1982	1983	1984	1985	1986
Aluminum, London Metal Exchange	cents/lb.	80.753	57.274	44.966	65.342	56.526	47.850	52.179
Antimony, New York dealer	$/lb.	1.508	1.355	1.072	0.913	1.512	1.311	1.219
Asbestos, No. 4T cement fibre	Cdn $/st	769.000	850.000	876.000	1 083.000	1 083.000	1 083.000	1 083.000
Bismuth, New York dealer	$/lb.	2.481	2.215	1.533	1.653	4.132	4.932	3.017
Cadmium, U.S. producer	$/lb.	2.843	1.927	1.113	1.129	1.693	1.208	1.248
Calcium, metal crowns	$/lb.	2.502	2.831	3.050	3.050	3.099	3.504	3.920
Chrome, U.S. metal, 9% carbon	$/lb.	4.017	4.450	4.450	4.450	4.450	4.450	3.021
Cobalt, metal, shot/cathode/250 kg	$/lb.	25.000	21.429[5]	12.500	12.500	12.417	11.700	11.242
Columbium, pyrochlore	$/lb.	2.550	3.250	3.250	3.250	3.250	3.209	2.600
Copper, electrolytic cathode, Comex	cents/lb.	96.758	78.655	65.820	71.902	61.320	60.988	61.649
Gold, London[3]	Cdn $/troy oz.	716.087	551.178	465.102	520.792	466.781	433.227	510.628
Iridium, Impala producer	$/troy oz.	505.833	600.000	600.000	600.000	600.000	600.000	600.000
Iron ore, taconite pellets	cents/ltu	69.562	80.073	80.500	80.500	80.500	80.500	80.500
Lead, producer	Cdn cents/lb.	49.350	44.520	32.887	26.770	33.517	26.179	30.885
Magnesium, U.S. primary ingot	$/lb.	1.167	1.303	1.340	1.365	1.455	1.480	1.530
Manganese, U.S. metal, regular	cents/lb.	65.267	70.000	86.274	67.583	73.542	80.000	79.450
Mercury, New York dealer	$/flask (76 lb.)	389.447	413.885	370.934	322.443	314.381	310.957	232.785
Molybdenum, dealer, oxide	$/lb.	9.359	6.400	4.100	3.635	3.557	3.247	2.871
Nickel, major producer, cathode	$/lb.	3.415	3.429	3.200	3.200	3.200	3.200	3.200
Osmium, New York dealer	$/troy oz.	130.000	130.000	130.000	133.113	466.479	913.125	698.854
Palladium, Impala producer	$/troy oz.	213.975	129.500	110.000	130.000	146.667	126.905	130.595
Platinum, Impala producer	$/troy oz.	439.425	475.000	475.000	475.000	475.000	475.000	519.147
Potash, K_2O, coarse, major producer, 60% contained	$/st	67.080	72.480	72.480	71.500	65.000	55.729	46.750
Rhodium, Impala producer	$/troy oz.	764.583	639.583	600.000	600.000	627.500	892.708	1 194.583
Ruthenium, New York dealer	$/troy oz.	35.288	32.212	25.615	28.529	104.183	100.269	73.423
Selenium, New York dealer	$/lb.	8.331	4.115	3.766	3.722	8.995	7.248	5.596
Silver, Handy & Harman, Toronto	Cdn $/troy oz.	24.099	12.617	9.831	14.154	10.828	8.674	7.862
Sulphur elemental, North American deliveries	Cdn $/mt	31.510	60.330	68.300	60.170	69.222	100.775	107.676
Tantalum, tantalite ore, spot	$/lb.	106.892	63.292	31.540	23.146	29.438	26.292	18.008
Tellurium, major producer, slab	$/lb.	19.770	14.000	10.000	9.000	11.000	11.000	10.000
Tin, New York dealer	$/lb.	7.734	6.484	5.869	6.013	5.678	5.257	2.941
Titanium, slag	$/lt	115.000	135.000	150.000	150.000	150.000	150.000	150.000
Tungsten, U.S. hydrogen red	$/lb.	13.900	13.900	13.350	13.100	13.100	13.100	13.100
Uranium, U_3O_8[4]	Cdn $/lb.	51.927	42.311	44.234	38.500	34.600	35.380	34.250
Vanadium, pentoxide, metallurgical	$/lb.	3.050	3.250	3.350	3.350	3.350	3.350	3.350
Zinc	Cdn cents/lb.	44.050	54.240	49.167	52.632	63.823	56.876	55.129

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[1] Prices, except where noted, are in United States currency. [2] Sources: Alberta Energy Resource Industries Monthly Statistics, Engineering and Mining Journal, Metals Week, Northern Miner and Mineral Commodity Summaries. [3] Average afternoon fixings of London bullion dealers, converted to Canadian dollar. [4] From EMR publications on assessment of Canada's uranium supply and demand. [5] Seven-month average.

TABLE 31. CANADIAN AVERAGE ANNUAL PRICES OF SELECTED MINERALS, 1980-86[1]

	Unit of Measure	1980	1981	1982	1983	1984	1985	1986
Aluminum, London Metal Exchange	$/kg	2.081	1.514	1.223	1.775	1.614	1.440	1.598
Antimony, New York dealer	$/kg	3.887	3.582	2.917	2.481	4.316	3.947	3.734
Asbestos, No. 4T cement fibre	$/t	847.677	936.964	965.625	1 193.800	1 193.800	1 193.800	1 193.800
Bismuth, New York dealer	$/kg	6.394	5.855	4.171	4.491	11.795	14.847	9.241
Cadmium, U.S. producer	$/kg	7.327	5.094	3.028	3.067	4.833	3.637	3.823
Calcium, metal crowns	$/kg	6.448	7.483	8.298	8.287	8.846	10.549	12.008
Chrome, U.S. metal, 9% carbon	$/kg	10.353	11.763	12.107	12.090	12.703	13.396	9.253
Cobalt, metal, shot/cathode/250 kg	$/kg	64.430	56.610[4]	34.009	33.961	35.446	35.222	34.436
Columbium, pyrochlore	$/kg	6.572	8.591	8.842	8.830	9.278	9.660	7.964
Copper, electrolytic cathode, Comex	$/kg	2.494	2.079	1.791	1.953	1.750	1.836	1.888
Gold, London[2]	$/g	23.023	17.721	14.953	16.744	15.007	13.929	16.417
Iridium, producer, Impala	$/g	19.011	23.129	23.806	23.773	24.978	26.341	26.802
Iron ore, taconite pellets	¢/mtu	80.034	94.490	97.776	97.638	102.588	108.187	110.082
Lead, producer	¢/kg	108.798	98.150	72.503	59.018	73.892	57.715	68.090
Magnesium, U.S. primary ingot	$/kg	3.007	3.443	3.646	3.709	4.154	4.455	4.687
Manganese, U.S. metal, regular	$/kg	1.682	1.850	2.347	1.836	2.099	2.408	2.434
Mercury, New York dealer	$/kg	13.206	14.395	13.279	11.527	11.808	12.317	9.382
Molybdenum, dealer, oxide	$/kg	24.120	16.917	11.155	9.876	10.154	9.775	8.794
Nickel, major producer, cathode	$/kg	8.801	9.064	8.706	8.695	9.136	9.633	9.802
Osmium, New York dealer	$/g	4.886	5.011	5.158	5.274	19.420	40.088	31.218
Palladium, producer, Impala	$/g	8.042	4.992	4.364	5.151	6.106	5.571	5.834
Platinum, producer, Impala	$/g	16.515	18.310	18.847	18.820	19.774	20.853	23.191
Potash, K_2O, coarse, major producer, 60% contained	$/t	86.440	95.793	98.599	97.128	92.775	83.884	71.601
Rhodium, producer, Impala	$/g	28.736	24.655	23.806	23.773	26.123	39.192	53.363
Ruthenium, New York dealer	$/g	1.326	1.242	1.016	1.130	4.337	4.402	3.280
Selenium, New York dealer	$/kg	21.471	10.877	10.246	10.112	25.677	21.820	17.141
Silver, Handy & Harman, Toronto	$/kg	774.801	405.646	316.074	455.062	348.140	269.791	252.769
Sulphur, elemental, North American deliveries	$/t	31.510	60.330	68.300	60.170	69.222	100.775	107.676
Tantalum ore, spot	$/kg	275.483	167.300	85.811	62.885	84.034	79.150	55.161
Tellurium, major producer, slab	$/kg	50.951	37.006	27.207	24.452	31.401	33.115	30.631
Tin, New York dealer	$/kg	19.932	17.139	15.968	16.337	16.209	15.826	9.009
Titanium, slag	$/t	132.312	159.306	182.191	181.933	194.225	201.591	205.121
Uranium, U[3]	$/kg	135.000	110.000	115.000	100.000	90.000	92.000	89.000
Vanadium, pentoxide, metallurgical	$/kg	7.861	8.591	9.114	9.102	9.564	10.080	10.260
Zinc, special high grade	$/kg	0.971	1.196	1.084	1.160	1.407	1.254	1.215

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[1] Sources: Alberta Energy Resource Industries Monthly Statistics, Engineering and Mining Journal, Metals Week and Northern Miner.
[2] Average afternoon fixings of London bullion dealers, converted to Canadian dollar. [3] From EMR publications on assessment of Canada's uranium supply and demand. [4] Seven-month average.

TABLE 32. CANADA, MINERAL PRODUCTS INDUSTRIES, SELLING PRICE INDEXES, 1981-86

(1981 = 100)	1981	1982	1983	1984	1985	1986P
Iron and steel products industries						
Agricultural implements industry	100.0	112.5	119.7	125.3	130.3	133.3
Hardware, tool and cutlery manufacturers	100.0	111.6	115.7	121.6	128.0	132.2
Heating equipment manufacturers	100.0	111.6	117.5	121.9	127.2	129.7
Primary steel industries	100.0	108.7	109.9	113.5	115.7	116.4
Ferro-alloy and steel foundries	100.0	104.3	104.1	110.5	113.3	114.7
Steel pipe and tube mills	100.0	109.8	108.9	111.0	112.1	112.4
Iron foundries	100.0	107.4	109.0	112.2	116.6	119.8
Wire and wire products manufacturers	100.0	106.7	107.2	113.0	115.5	116.4
Nonferrous metal products industries						
Aluminum rolling, casting and extruding	100.0	99.9	103.6	116.2	111.2	114.4
Copper and alloy, rolling, casting and extruding	100.0	93.4	99.2	91.4	93.0	95.9
Jewellery and silverware manufacturers	100.0	88.6	99.9	90.6	87.7	94.9
Metal rolling, casting and extruding, n.e.s.	100.0	96.6	99.7	106.6	100.9	102.3
Nonferrous metal smelting and refining industries	100.0	90.6	95.6	98.1	91.7	95.4
Nonmetallic mineral products industries						
Nonmetallic mineral insulating materials industries	100.0	110.6	112.7	113.4	120.8	121.8
Cement manufacturers	100.0	117.9	123.7	128.0	133.9	137.4
Clay products from imported clay	100.0	110.4	115.5	118.1	121.5	129.1
Glass and glass products manufacturers	100.0	109.4	114.5	119.0	121.1	125.8
Concrete products manufacturers	100.0	111.2	115.0	113.8	114.0	120.3
Clay products from domestic clay	100.0	112.8	120.5	130.7	143.0	150.7
Petroleum and coal products industries	100.0	115.7	121.8	127.1	133.5	107.4
Agricultural chemicals industries	100.0	102.5	100.2	103.8	104.2	101.8

n.e.s. Not elsewhere specified; P Preliminary.

TABLE 33. CANADA, SELLING PRICE INDEXES OF MINERAL RAW MATERIALS, 1981-86

(1981=100)	1981	1982	1983	1984	1985	1986P
Metallic materials						
Copper concentrates	100.0	88.0	92.4	80.8	86.6	89.5
Iron ore	100.0	103.5	105.2	109.5	114.0	115.6
Lead concentrates	100.0	70.6	57.5	73.1	56.7	66.5
Nickel concentrates	100.0	91.3	84.5	92.8	99.4	87.4
Other base metals, n.e.s.	100.0	90.5	95.3	104.8	94.8	96.9
Precious metals	100.0	82.5	99.0	84.9	77.2	86.7
Gold ingots	100.0	83.1	98.0	85.0	78.2	91.4
Silver	100.0	75.4	111.2	82.1	65.8	60.1
Platinum	100.0	76.5	99.6	87.5	74.1	121.5
Radioactive concentrates	100.0	110.3	98.5	95.1	91.9	91.1
Zinc concentrates	100.0	89.9	96.3	118.4	105.0	102.0
Nonmetal materials						
Asbestos	100.0	100.7	110.9	110.4	108.0	107.7
Other nonmetallic materials, n.e.s.	100.0	110.5	110.1	114.3	116.0	117.6
Sand and gravel	100.0	109.2	108.8	108.2	109.4	111.4
Silica sand	100.0	110.5	117.2	114.6	118.4	121.7
Stone	100.0	112.8	123.6	127.5	133.8	138.9
- building	100.0	112.0	123.2	127.6	132.9	136.5
- crushed	100.0	114.9	127.6	134.6	143.3	151.0
- other	100.0	112.0	123.2	127.6	132.9	136.5
Sulphur	100.0	112.8	98.9	114.4	167.2	177.5
Mineral fuels						
Coal, thermal	100.0	110.3	111.0	118.6	119.5	119.0
Oil, crude	100.0	120.6	130.0	131.8	138.9	71.9
Natural gas	100.0	127.6	134.3	131.4	131.6	129.3

n.e.s. Not elsewhere specified; P Preliminary.

TABLE 34. CANADA, PRINCIPAL STATISTICS OF THE MINERAL INDUSTRY[1], 1985

	Mining Activity								Total Activity[2]		
		Production and Related Workers			Costs						
	Establishments	Employees	Person-hours Paid	Wages	Fuel and Electricity	Materials and Supplies	Value of Production	Value Added	Employees	Salaries and Wages	Value Added
	(number)	(number)	(000)	($000)	($000)	($000)	($000)	($000)	(number)	($000)	($000)
Metals											
Gold	41	6 412	13 558	226 230	64 983	269 467	969 800	635 351	7 862	260 661	635 302
Silver-lead-zinc	14	3 389	7 202	120 020	50 714	548 501	887 245	288 030	4 724	180 028	275 341
Nickel-copper-zinc	28	15 966	33 757	532 557	207 699	1 506 959	3 552 150	1 837 491	22 073	769 955	1 868 527
Iron	9	5 190	10 932	192 391	218 016	376 817	1 415 931	821 097	7 077	271 162	817 068
Uranium	5	4 976	10 231	193 462	65 222	161 761	1 043 990	817 007	5 989	239 424	813 103
Misc. metal mines	7	685	1 468	24 331	12 184	30 733	108 176	65 259	947	35 158	65 357
Total	104	36 618	77 148	1 288 990	618 818	2 894 239	7 977 292	4 464 235	48 672	1 776 388	4 474 698
Industrials											
Asbestos	8	2 784	5 563	82 876	46 127	52 960	319 771	220 683	3 569	112 471	217 634
Gypsum	10	633	1 487	15 064	6 874	17 882	75 556	50 800	753	19 021	50 652
Peat	59	1 123	2 462	20 043	3 856	15 795	81 935	62 284	1 363	25 586	62 993
Potash	11	3 075	5 930	95 553	110 345	111 572	651 062	429 145	4 488	151 732	428 832
Sand and gravel	94	1 145	2 573	31 885	17 693	44 298	188 564	126 573	1 601	44 461	132 868
Stone	110	1 820	4 054	50 481	28 441	66 941	297 899	202 517	2 340	65 045	207 496
Misc. nonmetals	47	1 955	4 175	58 557	34 443	53 752	318 490	230 295	2 801	84 234	226 772
Total	339	12 535	26 244	354 460	247 779	363 199	1 933 276	1 322 298	16 915	502 550	1 327 245
Fuels											
Coal	30	9 194	18 317	366 033	138 960	348 374	1 753 647	1 266 313	11 860	492 304	1 264 502
Oil, crude and natural gas	913	8 273	17 688	319 331	259 062	836 546	26 463 592	25 367 984	34 108	1 418 492	25 428 653
Total	943	17 467	36 005	685 364	398 022	1 184 920	28 217 239	26 634 297	45 968	1 910 796	26 693 155
Total mineral industry	1 386	66 620	139 397	2 328 814	1 264 619	4 442 358	38 127 807	32 420 830	111 555	4 189 734	32 495 098

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[1] Cement manufacturing, lime manufacturing, clay and clay products (domestic clays) are included in the mineral manufacturing industry.
[2] Total activity includes sales and head offices.

TABLE 35. CANADA, PRINCIPAL STATISTICS OF THE MINERAL MANUFACTURING INDUSTRIES, 1985

		Mineral Manufacturing Activity							Total Activity[1]		
		Production and Related Workers			Costs						
	Establishments	Employees	Person-hours Paid	Wages	Fuel and Electricity	Materials and Supplies	Value of Shipments	Value Added	Employees	Salaries and Wages	Value Added
	(number)	(number)	(000)	($000)	($000)	($000)	($000)	($000)	(number)	($000)	($000)
Primary metal industries											
Primary steel	59	36 396	77 569	1 289 061	502 917	4 199 153	7 695 677	3 096 771	47 685	1 699 323	1 105 899
Steel pipe and tube	40	4 806	10 799	156 976	29 507	791 719	1 216 506	387 419	5 978	196 175	388 191
Iron foundries	101	6 470	13 935	182 557	44 280	274 196	777 188	469 028	7 750	228 925	471 519
Smelting and refining	30	21 443	43 572	769 990	434 357	1 931 807	4 595 599	2 187 463	30 567	1 151 737	2 202 355
Aluminum rolling, casting and extruding	70	4 755	10 658	143 015	42 986	901 250	1 343 709	376 232	6 196	201 222	386 285
Copper and alloy rolling, casting and extruding	19	2 545	5 272	66 553	15 204	547 923	501 763	138 571	3 012	79 638	134 683
Metal rolling, casting and extruding, n.e.s.	96	4 574	9 704	113 871	29 153	461 624	860 433	352 806	5 620	169 827	355 169
Total	435	80 989	171 409	2 660 807	1 088 392	8 906 869	16 970 955	7 006 289	106 808	3 707 867	7 042 100
Nonmetallic mineral products industries											
Cement	26	2 240	5 034	81 756	166 235	146 745	795 681	484 497	3 533	130 689	490 696
Lime	14	601	1 278	19 926	47 671	23 463	140 142	69 434	703	26 582	70 118
Concrete pipe	50	1 402	3 011	34 628	6 201	79 613	190 049	109 378	1 791	47 416	110 096
Structural concrete products	53	1 883	3 980	48 710	4 488	78 557	232 278	152 611	2 329	64 644	151 905
Other concrete products	288	3 757	7 599	77 570	15 993	158 636	369 234	196 946	4 216	93 904	201 934
Ready-mix concrete	584	7 599	15 672	203 311	53 281	704 361	1 196 666	437 980	9 210	253 876	455 336
Gypsum products	27	1 496	3 193	40 042	33 817	163 905	381 044	182 490	2 455	68 799	191 458
Clay products (domestic)	39	1 142	2 412	26 795	26 578	25 257	141 412	92 211	1 579	41 503	92 939
Clay products (imported)	49	954	1 873	16 763	4 318	18 451	62 174	40 617	1 148	21 910	41 365
Primary glass	10	5 863	12 378	165 542	71 328	187 712	731 342	468 552	7 758	232 071	466 440
Glass products	127	4 243	8 932	99 833	14 650	290 256	619 088	313 466	5 114	126 925	320 686
Abrasives	28	1 409	2 983	34 407	31 743	101 532	229 326	96 112	1 895	52 735	97 815
Refractory products	21	986	2 073	25 631	8 297	69 082	159 950	81 923	1 587	44 650	88 297
Mineral insulating products	39	2 044	4 369	57 740	34 288	142 550	317 580	142 771	3 372	104 466	211 242
Other nonmetallic mineral products	171	3 160	6 443	69 107	15 550	116 154	313 163	180 157	3 835	88 743	181 431
Total	1 532	38 763	81 238	1 001 780	533 838	2 303 654	5 879 141	3 047 145	50 605	1 398 911	3 171 754
Petroleum and coal products industries											
Petroleum refining products	33	5 545	12 601	241 441	359 867	20 777 440	23 990 750	2 504 330	15 326	681 414	2 478 816
Lubricating oils and greases	29	544	1 210	15 861	5 117	205 975	277 939	70 380	900	27 062	75 694
Other petroleum and coal products	59	347	703	8 557	5 505	107 146	152 139	39 500	513	13 585	40 956
Total	121	6 436	14 515	265 859	370 489	21 090 561	24 420 828	2 614 210	16 739	722 061	2 595 466
Total, mineral manufacturing industries	2 088	126 188	267 242	3 928 446	1 992 719	32 301 083	47 270 927	12 667 645	174 152	5 828 819	12 809 320

[1] Includes sales and head offices.
n.e.s. Not elsewhere specified.

TABLE 36. CANADA, PRINCIPAL STATISTICS OF THE MINERAL INDUSTRY[1] BY REGION, 1985

		Mines, Quarries and Oil Well Activity							Total Activity[2]		
		Production and Related Workers			Costs						
	Establishments	Employees	Person-hours Paid	Wages	Fuel and Electricity	Materials and Supplies	Value of Production	Value Added	Employees	Salaries and Wages	Value Added
	(number)	(number)	(000)	($000)	($000)	($000)	($000)	($000)	(number)	($000)	($000)
Atlantic[3]	109	7 402	15 471	220 118	145 200	550 976	1 445 015	748 838	9 798	303 560	762 465
Quebec	176	11 312	24 086	362 925	209 568	521 951	1 717 176	985 657	15 366	511 135	1 001 574
Ontario	138	18 689	39 188	637 338	204 276	1 159 641	3 727 506	2 363 591	24 885	881 980	2 376 543
Prairies	715	17 048	34 862	596 892	454 013	1 284 647	27 419 425	25 680 764	45 284	1 782 938	25 730 024
British Columbia[4]	193	9 547	19 008	386 113	207 117	676 039	3 057 648	2 174 492	12 530	536 127	2 166 163
Yukon and Northwest Territories[5]	55	2 622	6 782	125 428	44 445	249 104	761 037	467 488	3 692	173 993	458 329
Canada	1 386	66 620	139 397	2 328 814	1 264 619	4 442 358	38 127 807	32 420 830	111 555	4 189 733	32 495 098

[1] Cement manufacturing, lime manufacturing, clay and clay products are included in the mineral manufacturing industry. [2] Total activity includes sales and head offices. [3] Includes eastern Canada offshore. [4] Includes western Canada offshore. [5] Includes Arctic Islands and offshore.

TABLE 37. CANADA, PRINCIPAL STATISTICS OF THE MINERAL MANUFACTURING INDUSTRY BY REGION, 1985

		Mineral Manufacturing Activity							Total Activity[1]		
		Production and Related Workers			Costs						
	Establishments	Employees	Person-hours Paid	Wages	Fuel and Electricity	Materials and Supplies	Value of Shipments	Value Added	Employees	Salaries and Wages	Value Added
	(number)	(number)	(000)	($000)	($000)	($000)	($000)	($000)	(number)	($000)	($000)
Atlantic Provinces	132	X	X	X	X	X	X	X	X	X	X
Quebec	506	30 578	61 736	939 562	621 137	7 711 268	11 536 465	3 079 314	42 081	1 398 565	3 081 899
Ontario	837	71 362	154 091	2 237 325	958 653	13 857 241	21 195 147	6 358 094	98 549	3 311 379	6 457 471
Prairie Provinces	367	X	X	X	X	X	X	X	X	X	X
British Columbia	245	X	X	X	X	X	X	X	X	X	X
Yukon and Northwest Territories	1	X	X	X	X	X	X	X	X	X	X
Canada	2 088	126 188	267 242	3 928 446	1 992 719	32 301 083	47 270 927	12 667 645	174 152	5 828 819	12 809 320

[1] Includes sales and head offices.
X Confidential, included in Canadian total.

TABLE 38. CANADA, PRINCIPAL STATISTICS OF THE MINERAL INDUSTRY[1], 1979-85

	Mineral Manufacturing Activity								Total Activity[2]		
		Production and Related Workers			Costs						
	Establishments	Employees	Person-hours Paid	Wages	Fuel and Electricity	Materials and Supplies	Value of Production	Value Added	Employees	Salaries and Wages	Value Added
	(number)	(number)	(000)	($000)	($000)	($000)	($000)	($000)	(number)	($000)	($000)
1979	1 150	72 580	152 560	1 493 773	605 985	3 252 991	23 626 730	19 767 754	115 245	2 492 715	19 894 086
1980	1 322	80 066	166 427	1 779 388	706 406	3 802 062	27 566 272	23 057 804	126 422	2 979 470	23 252 708
1981	1 361	81 136	167 307	2 053 760	888 554	4 266 637	28 204 485	23 049 295	129 251	3 439 945	23 091 447
1982	1 249	74 958	142 626	2 025 895	956 296	3 768 771	29 101 618	24 376 549	123 486	3 648 004	24 442 997
1983	1 407	66 629	131 406	1 963 773	1 022 417	3 756 625	32 771 401	27 992 357	113 831	3 687 912	28 012 167
1984	1 381	69 400	140 110	2 285 256	1 204 009	4 290 972	37 976 019	32 481 039	115 790	4 106 049	32 545 725
1985	1 386	66 620	139 397	2 328 814	1 264 619	4 442 358	38 127 807	34 420 830	111 555	4 189 734	32 495 098

[1] Cement manufacturing, lime manufacturing, clay and clay products (domestic clays) are included in the mineral manufacturing industries. [2] Includes sales and head offices.

TABLE 39. CANADA, PRINCIPAL STATISTICS OF THE MINERAL MANUFACTURING INDUSTRIES, 1979-85

	Mineral Manufacturing Activity								Total Activity[1]		
		Production and Related Workers			Costs						
	Establishments	Employees	Person-hours Paid	Wages	Fuel and Electricity	Materials and Supplies	Value of Production	Value Added	Employees	Salaries and Wages	Value Added
	(number)	(number)	(000)	($000)	($000)	($000)	($000)	($000)	(number)	($000)	($000)
1979	2 115	145 929	308 770	2 614 816	1 118 146	19 116 369	28 318 690	8 522 128	202 695	3 910 454	8 669 240
1980	2 143	146 606	308 312	2 927 363	1 272 902	22 045 572	32 177 335	9 417 966	204 872	4 386 065	9 599 968
1981	2 124	140 914	293 781	3 187 784	1 560 453	28 125 138	39 495 229	10 862 006	203 051	4 932 893	11 062 937
1982	2 106	124 304	256 900	3 175 123	1 537 247	27 801 486	38 496 873	9 078 253	182 665	5 070 760	9 256 207
1983	2 143	119 093	246 101	3 281 473	1 701 521	29 177 081	41 675 029	10 580 670	171 719	5 128 268	10 759 467
1984	2 182	124 147	262 222	3 710 851	1 901 089	31 588 420	45 014 678	12 147 253	175 107	5 605 097	12 264 066
1985	2 088	126 188	267 242	3 928 446	1 992 719	32 301 083	47 270 927	12 667 645	174 152	5 828 819	12 809 320

[1] Includes sales and head offices.

TABLE 40. CANADA, CONSUMPTION OF FUEL AND ELECTRICITY IN THE MINERAL INDUSTRY[1], 1985

	Unit	Metals	Industrials[2]	Fuels	Total
Coal	000 t	175	-	-	175
	$000	8 517	-	-	8 517
Gasoline	000 litres	21 228	13 644	15 044	49 916
	$000	9 362	6 147	5 393	20 902
Fuel oil, kerosene, diesel oil	000 litres	875 513	230 142	242 599	1 348 254
	$000	253 446	75 782	72 374	401 602
Liquefied petroleum gas	000 litres	112 841	8 265	20 757	141 863
	$000	23 434	2 315	3 825	29 574
Natural gas	000 m^3	174 230	697 291	150 000	1 021 521
	$000	27 135	81 421	19 457	128 013
Other fuels[3]	$000	15 551	-	-	15 551
Total value of fuels	$000	337 445	165 665	101 049	604 159
Electricity purchased	million kWh	11 504	2 122	6 569	20 195
	$000	281 373	82 114	296 973	660 460
Total value of fuels and electricity purchased, all reporting companies	$000	618 818	247 779	398 022	1 264 619

Note: Totals may not add up due to rounding.

[1] Cement and lime manufacturing and manufacturers of clay products (domestic clays) are included under mineral manufacturing. [2] Includes structural materials. [3] Includes wood, manufactured gas, steam purchased and other miscellaneous fuels.

- Nil.

TABLE 41. CANADA, CONSUMPTION OF FUEL AND ELECTRICITY IN THE MINERAL MANUFACTURING INDUSTRIES, 1985

	Primary Metal Industries	Nonmetallic Mineral Products Industries	Petroleum and Coal Products Industries	Total
		($000)		
Coal and coke	47 022	56 224	-	103 246
Gasoline	5 759	8 304	1 393	15 456
Fuel oil, kerosene, diesel oil	124 740	71 594	2 709	199 043
Liquefied petroleum gas	9 857	3 585	5 563	19 005
Natural gas	374 553	203 069	240 194	817 816
Other fuels	13 935	38 096	8 886	60 917
Electricity purchased	512 526	152 967	111 744	777 236
Total value of fuels and electricity purchased	1 088 392	533 838	370 489	1 992 719

Note: Totals may not add due to rounding.
- Nil.

TABLE 42. CANADA, COST OF FUEL AND ELECTRICITY USED IN THE MINING INDUSTRY[1], 1979-85

	Unit	1979	1980	1981	1982	1983	1984	1985
Metals								
Fuel	$000	193 828	220 052	293 979	275 205	270 098	331 231	337 445
Electricity purchased	million kWh	11 459	11 024	10 494	9 891	9 659	11 672	11 504
	$000	153 905	174 837	209 316	232 137	238 458	272 932	281 373
Total cost of fuel and electricity	$000	347 733	394 889	503 295	507 942	508 556	604 169	618 818
Industrials[2]								
Fuel	$000	92 499	112 672	142 169	143 393	157 872	169 486	165 665
Electricity purchased	million kWh	2 244	2 269	2 100	1 782	1 928	2 120	2 122
	$000	42 982	48 336	56 297	57 567	64 052	76 884	82 114
Total cost of fuel and electricity	$000	135 481	161 008	198 466	200 960	221 924	246 370	247 779
Fuels								
Fuels	$000	23 988	32 582	46 991	70 484	68 800	89 237	101 049
Electricity purchased	million kWh	3 238	3 504	3 740	5 780	4 958	5 840	6 569
	$000	98 783	117 927	139 802	176 911	223 136	264 233	296 973
Total cost of fuel and electricity	$000	122 771	150 509	186 793	247 395	291 936	353 470	398 022
Total mining industry								
Fuel	$000	310 315	365 306	483 139	489 683	496 770	589 960	604 159
Electricity purchased	million kWh	16 941	16 797	16 334	17 453	16 546	19 632	20 195
	$000	295 670	341 100	405 415	466 614	525 646	614 049	660 460
Total cost of fuel and electricity	$000	605 985	706 406	888 554	956 297	1 022 416	1 204 009	1 264 619

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[1] Cement and lime manufacturing and manufacturers of clay products (domestic clays) are included in mineral manufacturing.
[2] Includes structural materials.

TABLE 43. CANADA, COST OF FUEL AND ELECTRICITY USED IN THE MINERAL MANUFACTURING INDUSTRIES, 1979-85

	Unit	1979	1980	1981	1982	1983	1984	1985
Primary metals								
Fuel	$000	357 775	421 426	538 175	526 073	555 381	605 177	575 867
Electricity purchased	million kWh	18 451	20 535	20 429	16 848	17 524	18 904	..
	$000	260 317	316 884	357 186	345 614	396 632	463 357	512 526
Total cost of fuel and electricity	$000	618 092	738 317	895 361	871 687	952 014	1 068 535	1 088 392
Nonmetallic mineral products								
Fuel	$000	280 846	271 481	333 061	328 566	342 315	368 216	380 871
Electricity purchased	million kWh	5 163	4 633	4 573	3 973	3 983	4 439	..
	$000	98 296	102 765	114 062	116 243	125 310	143 243	152 967
Total cost of fuel and electricity	$000	379 142	374 248	447 123	444 809	467 624	511 459	533 838
Petroleum and coal products								
Fuels	$000	74 968	88 311	137 463	134 303	187 624	221 369	258 745
Electricity purchased	million kWh	3 555	3 705	3 669	3 476	3 491	3 517	..
	$000	63 395	72 186	80 517	86 448	94 259	99 727	111 744
Total cost of fuel and electricity	$000	138 363	160 498	217 980	220 751	281 883	321 095	370 489
Total mineral manufacturing industries								
Fuel	$000	713 589	781 218	1 008 699	988 942	1 085 391	1 194 762	1 215 483
Electricity purchased	million kWh	27 169	28 873	28 671	24 297	24 997	26 860	..
	$000	422 008	491 834	551 765	548 305	616 201	706 327	777 236
Total cost of fuel and electricity	$000	1 135 597	1 273 063	1 560 464	1 537 247	1 701 521	1 901 089	1 992 719

.. Figures no longer available.

TABLE 44. CANADA, EMPLOYMENT, SALARIES AND WAGES IN THE MINING INDUSTRY[1], 1979-85

	Unit	1979	1980	1981	1982	1983	1984	1985
Metals								
Production and related workers	Number	41 541	47 592	49 586	44 261	37 270	39 181	36 618
Salaries and wages	$000	879 383	1 091 848	1 265 547	1 180 485	1 110 308	1 296 157	1 288 990
Annual average salary and wage	$	21 169	22 942	25 522	26 671	29 791	33 081	35 201
Administrative and office workers	Number	17 419	18 526	19 126	17 242	14 924	13 502	12 054
Salaries and wages	$000	428 639	504 316	585 120	585 249	533 517	518 644	487 398
Annual average salary and wage	$	24 608	27 222	30 593	33 943	35 749	38 412	38 979
Total metals								
Employees	Number	58 960	66 118	68 712	61 503	52 194	52 683	48 672
Salaries and wages	$000	1 308 022	1 596 165	1 850 667	1 765 734	1 643 825	1 814 801	1 776 388
Annual average salary and wage	$	22 185	24 141	26 933	28 710	31 495	34 447	36 497
Industrials								
Production and related workers	Number	16 633	16 645	15 666	12 848	12 768	13 008	12 535
Salaries and wages	$000	321 303	343 004	352 302	309 736	329 199	356 828	354 460
Annual average salary and wage	$	19 317	20 607	22 488	24 108	25 783	27 431	28 278
Administrative and office workers	Number	4 829	4 795	4 908	4 323	3 805	4 250	4 380
Salaries and wages	$000	106 776	116 932	128 852	129 116	114 656	138 012	148 090
Annual average salary and wage	$	22 114	24 386	26 253	29 867	30 133	32 473	33 811
Total industrials								
Employees	Number	21 462	21 440	20 574	17 171	16 573	17 258	16 915
Salaries and wages	$000	428 079	459 936	481 154	438 852	443 855	494 840	502 550
Annual average salary and wage	$	19 946	21 452	23 387	25 558	26 782	28 673	29 710
Fuels								
Production and related workers	Number	14 406	15 829	15 884	17 849	16 591	18 499	17 467
Salaries and wages	$000	293 087	344 537	435 911	535 673	524 264	672 018	685 364
Annual average salary and wage	$	20 345	21 766	27 443	30 011	31 599	35 025	39 238
Administrative and office workers	Number	20 417	23 035	24 081	26 963	28 473	29 986	28 501
Salaries and wages	$000	463 527	578 832	672 213	907 745	1 075 246	1 206 331	1 225 432
Annual average salary and wage	$	22 703	25 128	27 915	33 666	37 764	40 230	42 996
Total fuels								
Employees	Number	34 823	38 864	39 965	44 812	45 064	48 485	45 968
Salaries and wages	$000	756 614	923 369	1 108 124	1 443 418	1 599 510	1 878 349	1 910 796
Average annual salary and wage	$	21 727	23 759	27 727	32 211	35 494	38 741	41 568
Total mining								
Production and related workers	Number	72 580	80 066	81 136	74 958	66 629	70 688	66 620
Salaries and wages	$000	1 493 773	1 779 388	2 053 760	2 025 895	1 963 773	2 325 003	2 328 814
Average annual salary and wage	$	20 581	22 224	25 313	27 027	29 473	32 891	34 957
Administrative and office workers	Number	42 665	46 356	48 115	48 528	47 202	47 738	44 935
Salaries and wages	$000	998 942	1 200 081	1 386 184	1 622 110	1 724 139	1 862 987	1 860 920
Annual average salary and wage	$	23 414	25 888	28 810	33 426	36 527	39 025	41 414
Total mining								
Employees	Number	115 245	126 422	129 251	123 486	113 831	118 426	111 555
Salaries and wages	$000	2 492 715	2 979 470	3 439 945	3 648 004	3 687 912	4 187 990	4 189 734
Annual average salary and wage	$	21 630	23 568	26 614	29 542	32 398	35 364	37 558

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[1] Does not include cement and lime manufacturing and clay products (domestic clays) manufacturing.

TABLE 45. CANADA, EMPLOYMENT, SALARIES AND WAGES IN THE MINERAL MANUFACTURING INDUSTRIES, 1979-85

	Unit	1979	1980	1981	1982	1983	1984	1985
Primary metal industries								
Production and related workers	Number	95 962	97 530	92 337	82 186	77 579	81 454	80 989
Salaries and wages	$000	1 725 904	1 980 423	2 120 019	2 157 186	2 216 614	2 566 420	2 660 807
Annual average salary and wage	$	17 989	20 306	22 960	26 248	28 572	31 485	32 966
Administrative and office workers	Number	30 812	28 920	32 831	31 029	27 773	27 496	25 849
Salaries and wages	$000	713 279	787 022	938 790	1 010 967	966 429	1 033 620	1 047 040
Annual average salary and wage	$	23 149	27 214	28 595	32 577	34 725	37 592	40 506
Total primary metal industries								
Employees	Number	126 774	126 450	125 168	113 215	105 352	108 950	106 838
Salaries and wages	$000	2 439 183	2 767 445	3 058 809	3 168 153	3 183 043	3 599 040	3 707 847
Annual average salary and wage	$	19 188	21 886	24 438	27 982	30 136	33 025	34 715
Nonmetallic mineral products industries								
Production and related workers	Number	41 813	40 799	40 145	33 997	34 097	36 155	38 763
Salaries and wages	$000	710 622	743 254	818 566	751 915	800 755	883 604	1 001 780
Annual average salary and wage	$	16 995	18 217	20 390	22 117	23 485	24 439	25 844
Administrative and office workers	Number	14 935	15 287	15 124	13 952	13 353	12 738	11 842
Salaries and wages	$000	297 211	333 815	369 899	383 405	391 901	394 619	397 129
Annual average salary and wage	$	19 900	21 837	24 458	27 480	29 349	30 980	33 556
Total nonmetallic mineral products								
Employees	Number	56 748	56 086	55 269	47 969	47 450	48 893	50 605
Salaries and wages	$000	1 007 833	1 077 069	1 188 465	1 135 320	1 192 656	1 278 223	1 398 909
Annual average salary and wage	$	17 760	19 203	21 503	23 679	25 135	26 145	27 644
Petroleum and coal products industries								
Production and related workers	Number	8 174	8 277	8 432	8 121	7 417	6 538	6 436
Salaries and wages	$000	185 290	203 686	249 199	266 022	264 104	262 827	265 859
Annual average salary and wage	$	22 668	24 609	29 554	32 757	35 608	40 200	41 308
Administrative and office workers	Number	11 019	11 769	14 182	13 380	11 500	10 726	10 303
Salaries and wages	$000	285 148	337 865	436 430	501 385	490 465	466 006	456 202
Annual average salary and wage	$	25 887	28 708	30 775	37 473	42 649	43 446	44 279
Total petroleum and coal products								
Employees	Number	19 193	20 046	22 614	21 501	18 917	17 264	16 739
Salaries and wages	$000	470 438	541 551	685 629	767 407	754 569	728 833	722 061
Annual average salary and wage	$	24 511	27 015	30 319	35 692	39 888	42 217	43 156
Total mineral manufacturing								
Production and related workers	Number	145 949	146 606	140 914	124 304	119 093	124 147	126 188
Salaries and wages	$000	2 621 816	2 927 365	3 187 784	3 175 123	3 281 475	3 710 851	3 929 446
Annual average salary and wage	$	17 966	19 968	22 622	25 543	27 554	29 891	31 132
Administrative and office workers	Number	56 766	55 976	62 137	58 359	52 626	50 960	47 994
Salaries and wages	$000	1 295 638	1 458 702	1 745 109	1 895 637	1 846 795	1 894 246	1 900 371
Annual average salary and wage	$	22 824	26 099	28 085	32 482	35 093	37 171	39 621
Total mineral manufacturing industries								
Employees	Number	202 695	202 582	203 051	182 663	171 719	175 107	174 152
Salaries and wages	$000	3 910 454	4 386 065	4 932 893	5 070 760	5 128 268	5 605 097	5 828 819
Annual average salary and wage	$	19 292	21 651	24 296	27 760	29 864	32 010	33 470

TABLE 46. CANADA, NUMBER OF WAGE EARNERS EMPLOYED IN THE MINING INDUSTRY (SURFACE, UNDERGROUND AND MILL), 1979-85

	1979	1980	1981	1982	1983	1984	1985
Metals							
Surface	12 664	14 347	14 043	12 133	9 970	9 724	10 093
Underground	15 906	19 308	19 784	18 673	15 861	16 668	14 798
Mill	12 971	13 937	15 759	13 455	11 439	12 789	11 727
Total	41 541	47 592	49 586	44 261	37 270	39 181	36 618
Industrials							
Surface	6 877	6 510	6 015	4 833	4 951	4 948	4 921
Underground	2 370	2 550	2 606	2 055	2 192	2 487	2 337
Mill	7 386	7 585	7 045	5 960	5 625	5 573	5 277
Total	16 633	16 645	15 666	12 848	12 768	13 008	12 535
Fuels							
Surface	9 500	10 550	11 429	12 786	12 190	15 430	14 413
Underground	2 871	2 900	2 926	3 226	2 896	1 818	1 626
Mill	2 035	2 379	1 529	1 837	1 505	1 251	1 428
Total	14 406	15 829	15 884	17 849	16 591	18 499	17 467
Total mining industry							
Surface	29 041	31 407	31 487	29 752	27 111	30 102	29 427
Underground	21 147	24 758	25 316	23 954	20 949	20 973	18 761
Mill	22 392	23 901	24 333	21 252	18 569	19 613	18 432
Total	72 580	80 066	81 136	74 958	66 629	70 688	66 620

TABLE 47. CANADA, MINE AND MILL WORKERS BY SEX, 1985

	Mine workers				Mill workers		Total	
	Underground		Surface					
	Male	Female	Male	Female	Male	Female	Male	Female
Metallic minerals								
Nickel-copper-zinc	7 681	9	4 544	101	3 503	128	15 728	238
Gold	3 280	5	1 184	38	1 881	24	6 345	67
Iron ore	101	1	1 398	11	3 607	72	5 106	84
Uranium	2 102	11	1 876	35	867	85	4 845	131
Silver-lead-zinc	1 465	7	474	36	1 356	51	3 295	94
Miscellaneous metal mines	136	-	384	12	152	1	672	13
Total	14 765	33	9 860	233	11 366	361	35 991	627
Industrial minerals								
Asbestos	296	-	744	4	1 686	54	2 726	58
Potash	1 499	19	74	1	1 502	35	3 020	55
Miscellaneous nonmetals	440	-	358	10	1 118	29	1 916	39
Stone	4	-	1 626	7	179	4	1 809	11
Peat	-	-	588	8	510	17	1 098	25
Sand and gravel	-	-	1 085	8	52	-	1 137	8
Gypsum	134	-	408	-	91	-	633	-
Total	2 318	19	4 883	38	5 138	139	12 339	196
Fuels								
Coal	1 626	-	6 038	102	1 391	37	9 055	139
Mining Total	18 709	52	20 781	373	17 895	537	57 385	962

- Nil.

TABLE 48. CANADA, LABOUR COSTS FOR METAL MINES IN RELATION TO TONNES MINED, 1983-85

Type of Metal Mine	Number of Wage Earners	Total Wages ($000)	Average Annual Wage ($)	Tonnage of Ore Mined (kilotonnes)	Average Annual Tonnes Mined per Wage Earner	Wage Cost per Tonne Mined ($)
1983						
Uranium	3 302	117,056	35,450	7 073	2 142	16.55
Gold	4 403	136,370	30,971	9 553	2 170	14.27
Silver-lead-zinc	2 157	76,949	35,674	9 157	4 245	8.40
Miscellaneous metals	320	10,959	34,248	2 133	6 665	5.14
Nickel-copper-zinc	14 133	374,211	26,478	116 532	8 245	3.21
Iron ore	1 516	50,509	33,317	74 597	49 206	0.68
Total	25 831	766,053	29,656	219 045	8 480	3.50
1984						
Uranium	3 885	139,466	35,889	7 608	1 958	18.33
Gold	4 800	161,233	33,590	11 225	2 339	14.36
Silver-lead-zinc	2 057	81,269	39,509	10 084	4 902	8.06
Miscellaneous metals	519	17,088	32,925	3 627	6 989	4.71
Nickel-copper-zinc	13 575	425,836	31,369	124 683	9 185	3.41
Iron ore	1 556	56,874	36,552	89 210	57 333	0.64
Total	26 392	881,766	33,410	246 437	9 338	3.58
1985						
Uranium	4 024	158,110	39,292	7 183	1 785	22.01
Gold	4 507	162,094	35,965	11 997	2 661	13.51
Silver-lead-zinc	1 982	73,202	36,933	9 970	5 030	7.34
Miscellaneous metals	532	18,412	34,609	4 068	7 646	4.53
Nickel-copper-zinc	12 335	415,630	33,695	117 169	9 499	3.54
Iron ore	1 511	58,147	38,482	94 588	62 599	0.62
Total	24 891	885,595	35,579	244 973	9 842	3.62

TABLE 49. CANADA, PERSON-HOURS PAID FOR PRODUCTION AND RELATED WORKERS, AND TONNES OF ORE MINED AND ROCK QUARRIED IN METAL MINES AND OTHER MINERAL OPERATIONS, 1979-85

	Unit	1979	1980	1981	1982	1983	1984	1985
Metal mines[1]								
Ore mined	million t	274.8	290.1	301.5	238.4	219.0	246.4	245.0
Person-hours paid[2]	million	85.1	97.5	100.6	80.4	71.8	78.2	77.1
Person-hours paid per tonne mined	number	0.31	0.34	0.33	0.34	0.33	0.32	0.31
Tonnes mined per person-hour paid	t	3.23	2.98	3.00	2.97	3.05	3.15	3.18
Other mineral operations[3]								
Ore mined and rock quarried	million t	105.1	106.6	110.5	93.2	101.6	132.3	138.2
Person-hours paid[2]	million	40.4	41.4	38.6	34.8	32.2	34.0	31.3
Person-hours paid per tonne mined	number	0.38	0.39	0.35	0.37	0.31	0.26	0.23
Tonnes mined per person-hour paid	t	2.60	2.58	2.86	2.68	3.15	3.89	4.41

[1] Excludes placer mining. [2] Person-hours paid for production and related workers only.
[3] Includes asbestos, potash, gypsum and coal.

TABLE 50. CANADA, AVERAGE WEEKLY WAGES AND HOURS WORKED (INCLUDING OVERTIME) FOR HOURLY-RATED EMPLOYEES IN MINING, MANUFACTURING AND CONSTRUCTION INDUSTRIES, 1980-86

	1980	1981	1982	1983[1]	1984	1985	1986
Mining							
Average hours per week	40.8	40.4	39.6	38.8	39.3	39.6	39.7
Average weekly wage ($)	440.61	494.62	551.68	552.79	664.57	697.98	710.98
Metals							
Average hours per week	40.1	40.2	39.0	38.3	38.8	39.1	39.6
Average weekly wage ($)	425.08	485.03	535.92	565.60	610.91	639.92	657.62
Mineral fuels							
Average hours per week	41.2	41.3	42.1	39.7	40.6	41.1	40.9
Average weekly wage ($)	476.30	553.71	631.91	626.12	672.85	716.33	711.40
Nonmetals							
Average hours per week	39.5	38.7	37.2	37.5	38.7	39.2	39.6
Average weekly wage ($)	402.98	445.02	479.44	468.05	536.93	555.33	581.84
Manufacturing							
Average hours per week	38.5	38.5	37.7	38.4	38.5	38.8	38.8
Average weekly wage ($)	314.80	352.08	384.79	504.76	465.64	488.14	504.10
Construction							
Average hours per week	39.0	38.9	38.1	36.9	37.2	37.7	32.7
Average weekly wage ($)	470.45	531.54	564.33	512.26	490.95	504.34	509.86

[1] Ten-month average; new time series.

TABLE 51. CANADA, AVERAGE WEEKLY WAGES (INCLUDING OVERTIME) OF HOURLY-RATED EMPLOYEES IN THE MINING INDUSTRY, IN CURRENT AND 1981 DOLLARS, 1980-86

	1980	1981	1982	1983	1984[1]	1985	1986
Current dollars							
All mining	440.61	494.62	551.68	552.79	664.57	697.98	710.98
Metals	425.08	485.03	535.92	565.60	610.91	639.92	657.62
Mineral fuels	476.30	553.11	631.91	626.12	672.85	716.33	711.40
Coal	430.16	485.03	562.12	564.18	653.52	697.48	718.82
Industrial minerals	402.98	445.02	479.44	504.76	536.93	555.33	581.84
1981 dollars							
All mining	495.62	494.62	497.90	471.66	543.39	548.73	536.99
Metals	478.16	485.03	483.68	482.59	499.52	503.08	496.69
Mineral fuels	535.77	553.11	570.32	534.23	550.16	563.15	537.31
Coal	483.87	485.03	507.33	481.38	534.36	548.33	542.92
Industrial minerals	453.30	445.02	432.71	430.68	439.03	436.58	439.46

[1] Ten-month average; new time series.

TABLE 52. CANADA, INDUSTRIAL FATALITIES PER THOUSAND WORKERS[1] BY INDUSTRY GROUPS, 1984-86

	Fatalities			Number of Workers			Rate per 1 000 Workers[2]		
	1984	1985	1986P	1984	1985	1986P	1984	1985	1986P
	(number)[1]			(000)					
Agriculture	20	20	4	156.0	168.0	172.0	0.13	0.12	0.02
Forestry	60	66	52	57.0	55.0	50.0	1.05	1.20	1.04
Fishing[3]	27	26	14	14.0	12.0	14.0	1.93	2.17	1.00
Mining[4]	105	131	79	148.6	156.6	146.0	0.71	0.84	0.54
Manufacturing	129	127	79	1 669.7	1 703.9	1 739.2	0.08	0.07	0.05
Construction	145	134	109	342.5	384.3	395.7	0.42	0.35	0.28
Transportation[5]	123	132	101	796.5	804.5	799.1	0.15	0.16	0.13
Trade	53	76	47	1 554.5	1 621.3	1 662.1	0.03	0.05	0.03
Finance[6]	10	5	4	535.9	556.6	577.9	0.02	0.01	0.01
Service[7]	62	50	25	2 890.9	3 051.0	3 141.8	0.02	0.02	0.01
Public administration	66	56	46	658.0	662.0	666.2	0.10	0.08	0.07
Unknown	12	18	3	..	..	..	..	..	..
Total	812	841	563	8 823.6	9 175.2	9 364.0	0.09	0.09	0.06

[1] Includes fatalities resulting from occupational chest illnesses such as silicosis, lung cancer, etc. [2] The rates may be understated because only 80 per cent of workers in the Statistics Canada employment estimates are covered by workers' compensation. [3] Includes trapping and hunting. [4] Includes quarrying and oil wells. [5] Includes storage, communication, electric power and water utilities and highway maintenance. [6] Includes insurance and real estate. [7] Includes community, business and personnel service.

P Preliminary; .. Not available.

TABLE 53. CANADA, INDUSTRIAL FATALITIES PER THOUSAND WORKERS BY INDUSTRY GROUPS, 1980-86[1]

	1980	1981	1982	1983	1984	1985	1986P[2]
Agriculture	0.05	0.14	0.13	0.13	0.13	0.12	0.02
Forestry	1.14	0.95	1.22	1.11	1.05	1.20	1.04
Fishing[3]	1.60	1.47	1.58	1.00	1.93	2.17	1.00
Mining[4]	1.08	0.76	0.96	0.68	0.71	0.84	0.54
Manufacturing	0.09	0.09	0.11	0.08	0.08	0.07	0.05
Construction	0.42	0.39	0.35	0.33	0.42	0.35	0.28
Transportation[5]	0.27	0.25	0.22	0.17	0.15	0.16	0.13
Trade	0.05	0.04	0.04	0.04	0.03	0.05	0.03
Finance[6]	0.01	0.02	0.01	0.01	0.02	0.01	0.01
Service[7]	0.03	0.03	0.03	0.03	0.02	0.02	0.01
Public administration	0.07	0.11	0.08	0.08	0.10	0.08	0.07
Total	0.13	0.11	0.11	0.09	0.09	0.09	0.06

[1] Includes fatalities resulting from occupational chest illnesses such as silicosis, lung cancer, etc. [2] The rates may be understated because only 80 per cent of workers in the Statistics Canada employment estimates are covered by workers' compensation. [3] Includes trapping and hunting. [4] Includes quarrying and oil wells. [5] Includes storage, communication, electric power and water utilities and highway maintenance. [6] Includes insurance and real estate. [7] Includes community, business and personnel service.
P Preliminary.

TABLE 54. CANADA, INDUSTRIAL FATALITIES BY OCCUPATIONAL INJURIES AND ILLNESSES[1], 1984-86

	Occupational Injuries			Occupational Illnesses[2]			Total		
	1984	1985	1986P	1984	1985	1986P	1984	1985	1986P
Agriculture	15	16	3	0	0	0	15	16	3
Forestry	56	59	45	0	1	0	56	60	45
Fishing	27	22	14	0	0	0	27	22	14
Mining	47	69	40	48	55	32	95	124	72
Manufacturing	82	81	59	34	28	14	116	109	73
Construction	98	89	80	18	25	19	116	114	99
Transportation	99	110	94	8	4	3	107	114	97
Trade	36	59	36	2	4	2	38	63	38
Finance	5	3	3	0	0	0	5	3	3
Service	49	29	17	0	2	1	49	31	18
Public administration	42	33	38	5	4	2	47	37	40
Unknown	1	2	0	0	1	0	1	3	0
Total	557	572	429	115	124	73	672	696	502

[1] Excludes the Province of Quebec for which data is unavailable. [2] Includes fatalities resulting from occupational chest illnesses such as silicosis, lung cancer, etc.
P Preliminary.

TABLE 55. CANADA, NUMBER OF STRIKES AND LOCKOUTS BY INDUSTRIES, 1984-86

	1984			1985			1986P		
	Strikes and Lockouts	Workers Involved	Duration in Person-days	Strikes and Lockouts	Workers Involved	Duration in Person-days	Strikes and Lockouts	Workers Involved	Duration in Person-days
Agriculture	2	123	190	1	16	290	0	0	0
Forestry	9	952	9 580	7	1 303	4 830	9	27 813	2 024 930
Fishing and trapping	0	0	0	0	0	0	0	0	0
Mines	9	2 029	37 120	12	6 350	91 590	14	8 796	351 870
Manufacturing	343	107 973	2 373 170	356	66 888	1 510 180	319	55 024	1 386 930
Construction	36	19 500	212 700	14	992	11 210	48	151 941	1 963 500
Transportation and utilities	48	20 091	550 340	97	38 994	487 070	59	23 859	305 270
Trade	101	5 721	188 220	131	23 978	471 980	111	8 508	238 540
Finance, insurance and real estate	23	559	26 230	18	1 136	112 030	13	885	32 570
Service	112	26 417	415 660	162	17 592	381 230	127	133 835	323 355
Public administration	34	3 390	70 190	31	5 982	55 050	41	73 206	506 860
Various industries	0	0	0	0	0	0	0	0	0
All industries	717	186 755	3 883 400	829	162 231	3 125 460	741	483 867	7 133 825

P Preliminary.

TABLE 56. CANADA, NUMBER OF STRIKES AND LOCKOUTS BY MINING AND MINERAL MANUFACTURING INDUSTRIES, 1984-86

	1984			1985			1986P		
	Strikes and Lockouts	Workers Involved	Duration in Person-days	Strikes and Lockouts	Workers Involved	Duration in Person-days	Strikes and Lockouts	Workers Involved	Duration in Person-days
Mines	9	2 029	37 120	12	6 350	91 590	14	8 796	351 870
Metals	6	1 755	36 240	5	4 018	40 760	7	4 700	52 920
Mineral fuels	0	0	0	2	1 400	13 030	4	2 977	231 870
Nonmetals	2	261	570	3	876	37 260	3	1 119	67 080
Quarries	1	13	310	2	56	540	0	0	0
Mineral manufacturing	35	6 378	163 160	38	4 050	130 730	41	7 136	228 070
Primary metals	17	3 684	41 920	16	2 789	63 400	14	4 422	138 750
Nonmetallic mineral products	16	2 209	119 480	22	1 261	67 330	26	2 598	89 070
Petroleum and coal products	2	485	1 760	0	0	0	1	116	250

P Preliminary.

TABLE 57. CANADA, SOURCE OF ORES HOISTED OR REMOVED FROM SELECTED TYPES OF MINES, 1983-85

Mines	1983			1984			1985		
	Under-ground	Open-pit	Total	Under-ground	Open-pit	Total	Under-ground	Open-pit	Total
					(kilotonnes)				
Nickel-copper-zinc	25 078	91 454	116 532	29 916	94 766	124 683	30 184	86 985	117 169
Iron ore	2 803	71 794	74 597	1 796	87 414	89 210	1 953	92 634	94 588
Coal	5 259	49 558	54 817	4 777	66 430	71 207	3 823	72 844	76 667
Asbestos	1 511	13 524	15 035	1 691	14 035	15 725	1 488	15 630	17 118
Gold	7 497	2 056	9 553	8 293	2 932	11 225	8 424	3 573	11 997
Silver-lead-zinc	7 726	1 431	9 157	7 767	2 317	10 084	7 183	2 787	9 970
Gypsum	873	6 667	7 540	1 199	7 670	8 869	1 100	8 508	9 608
Uranium	6 259	814	7 073	7 002	606	7 608	6 627	555	7 183
Miscellaneous metals	528	1 605	2 133	1 582	2 045	3 627	1 288	2 779	4 068
Total	57 534	238 903	296 437	64 023	278 215	342 238	62 070	286 296	348 366
Percentage	19.4	80.6	100.0	18.7	81.3	100.0	17.8	82.2	100.0

TABLE 58. CANADA, SOURCE OF MATERIAL HOISTED OR REMOVED FROM METAL MINES, 1985

	Underground		Open-pit		
	Ore	Waste	Ore	Waste	Overburden
			(kilotonnes)		
Nickel-copper-zinc	30 184	4 071	86 985	71 223	59 385
Iron	1 953	20	92 634	40 529	7 372
Gold	8 424	1 853	3 573	7 395	5 516
Silver-lead-zinc	7 183	1 377	2 787	10 072	16 817
Uranium	6 627	294	555	2 521	3 858
Miscellaneous metals	1 288	40	2 779	1 686	-
Total	55 660	7 656	189 314	133 426	92 948

- Nil.

TABLE 59. CANADA, ORE MINED AND ROCK QUARRIED IN THE MINING INDUSTRY, 1979-85

	1979	1980	1981	1982	1983	1984	1985
				(kilotonnes)			
Metals							
Nickel-copper-zinc	109 437	121 399	137 709	117 833	116 532	124 683	117 169
Iron	130 799	123 107	118 579	81 963	74 597	89 210	94 588
Gold	5 478	6 346	6 810	8 368	9 553	11 225	11 997
Silver-lead-zinc	15 078	16 219	15 964	14 113	9 157	10 084	9 970
Uranium	6 141	7 152	7 454	7 608	7 073	7 608	7 183
Miscellaneous metals	7 822	15 871	15 014	8 477	2 133	3 627	4 068
Total	274 755	290 095	301 530	238 362	219 045	246 437	244 973
Nonmetals							
Potash	25 511	26 988	30 344	16 946	24 222	36 542	34 843
Asbestos	31 522	28 103	25 664	17 493	15 035	15 725	17 118
Gypsum	8 310	7 611	6 220	5 830	7 540	8 869	9 608
Rock salt	5 639	5 321	4 927	5 723	5 996	6 706	7 101
Total	70 982	68 023	67 155	45 992	52 793	67 842	68 670
Structural materials							
Stone, all kinds quarried[1]	109 719	103 366	86 860	59 181	67 651	81 754	86 632
Stone used to make cement	13 982	14 138	14 047	10 593	10 154	10 101	8 466
Stone used to make lime	3 028	4 751	1 626	3 411	3 446	4 260	5 137
Total	126 729	122 255	102 533	73 085	81 251	96 115	100 236
Fuels							
Coal	39 755	43 930	48 237	52 979	54 817	71 207	76 668
Total ore mined and rock quarried	512 221	524 303	519 455	410 418	407 906	481 601	490 547

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[1] Excludes stone used to manufacture cement and lime in Canada.

TABLE 60. CANADA, EXPLORATION AND CAPITAL EXPENDITURES IN THE MINING INDUSTRY[1] BY PROVINCES AND TERRITORIES, 1985-87

		Capital						Repair					
		Construction											
		On-property exploration	On-property development	Structures	Total	Machinery and equipment	Total capital	Construction	Machinery and equipment	Total repair	Total capital and repair	Outside or general exploration	Total, all expenditures
							($ million)						
Newfoundland	1985	x	25.1	x	27.0	7.1	34.1	x	x	108.8	142.9	7.1	150.0
	1986P	0.8	36.1	0.5	37.4	28.0	65.4	x	x	112.2	177.6	7.8	185.4
	1987[i]	2.0	38.2	40.1	80.3	19.1	99.4	x	x	105.7	205.1	13.3	218.4
Prince Edward Island	1985	-	-	-	-	-	-	-	-	-	-	-	-
	1986P	-	-	-	-	-	-	-	-	-	-	-	-
	1987[i]	-	-	-	-	-	-	-	-	-	-	-	-
Nova Scotia	1985	x	x	x	133.0	74.6	207.6	1.1	20.5	21.6	229.2	10.8	240.0
	1986P	x	x	36.3	115.5	58.2	173.7	2.5	16.6	19.1	192.8	7.2	200.0
	1987[i]	x	x	11.9	80.4	49.9	130.3	2.5	20.3	22.8	153.1	6.9	160.0
New Brunswick	1985	x	x	72.2	95.0	92.3	187.3	6.6	52.8	59.4	246.7	10.2	256.9
	1986P	x	38.4	x	46.1	53.0	99.1	6.6	60.1	66.7	165.8	7.8	173.6
	1987[i]	x	20.7	x	27.7	45.0	72.7	7.2	61.8	69.0	141.7	8.3	150.0
Quebec	1985	28.1	180.5	69.9	278.5	67.8	346.3	31.2	197.3	228.5	574.8	133.9	708.7
	1986P	32.2	150.1	72.7	255.0	60.4	315.4	22.1	185.6	207.7	523.1	221.1	744.2
	1987[i]	26.1	117.1	33.3	176.5	60.3	236.8	21.3	187.1	208.4	445.2	269.7	714.9
Ontario	1985	24.7	264.2	159.7	448.6	142.5	591.1	45.4	341.7	387.1	978.2	92.4	1 070.6
	1986P	22.0	280.2	67.7	369.9	147.8	517.7	39.8	337.7	377.5	895.2	109.6	1 004.8
	1987[i]	18.2	303.8	62.8	384.8	196.3	581.1	40.5	341.6	382.1	963.2	148.6	1 111.8
Manitoba	1985	6.4	48.7	18.1	73.2	18.6	91.8	x	x	39.7	131.5	34.9	166.4
	1986P	6.6	47.8	10.9	65.3	34.6	99.9	x	x	34.6	134.5	17.5	152.0
	1987[i]	24.3	38.3	13.6	76.2	14.4	90.6	x	x	40.3	130.9	14.9	145.8
Saskatchewan	1985	11.0	43.3	70.2	124.5	122.9	247.4	16.8	139.4	156.2	403.6	30.9	434.5
	1986P	x	x	25.0	64.0	90.7	154.7	8.9	132.8	141.7	296.4	18.6	315.0
	1987[i]	x	22.5	x	45.8	78.0	123.8	8.7	139.9	148.6	272.4	14.7	287.1
Alberta	1985	2.0	17.0	20.4	39.4	26.1	65.5	5.8	54.6	60.4	125.9	19.5	145.4
	1986P	2.4	7.8	1.7	11.9	24.4	36.3	x	x	73.1	109.4	5.5	114.9
	1987[i]	x	x	5.2	18.9	25.2	44.1	3.2	70.3	73.5	117.6	5.0	122.6
British Columbia	1985	7.2	232.3	105.2	344.7	105.2	449.9	21.1	378.6	399.7	849.6	92.9	942.5
	1986P	9.1	109.4	51.2	169.7	89.5	259.2	15.9	362.7	378.6	637.8	59.6	697.4
	1987[i]	x	138.4	x	210.9	101.9	312.8	16.1	370.7	386.8	699.6	70.4	770.0
Yukon	1985	2.8	x	x	3.6	0.2	3.8	x	x	1.4	5.2	19.2	24.4
	1986P	x	1.7	x	2.8	0.5	3.3	x	x	1.2	4.5	10.5	15.0
	1987[i]	x	3.3	x	4.4	1.4	5.8	x	x	1.1	6.9	11.9	18.8
Northwest Territories	1985	13.7	42.2	3.7	59.6	15.2	74.8	6.7	50.2	56.9	131.7	37.0	168.7
	1986P	14.9	26.8	4.0	45.7	8.8	54.5	3.0	49.0	52.0	106.5	18.4	124.9
	1987[i]	x	18.4	x	35.6	10.5	46.1	3.2	43.4	46.6	92.7	19.4	112.1
Canada	1985	100.1	931.8	595.3	1 627.1	672.5	2 299.6	143.8	1 375.9	1 519.7	3 819.3	488.8	4 308.1
	1986P	110.2	797.3	276.1	1 183.3	595.9	1 779.2	109.9	1 354.5	1 464.4	3 243.6	483.6	3 727.2
	1987[i]	122.6	774.7	244.3	1 141.5	602.0	1 743.5	110.3	1 336.6	1 486.9	3 229.4	583.2	3 811.6

[1] Excludes crude oil and natural gas industries.

P Preliminary; [i] Intentions; x Confidential, included in total; - Nil.

TABLE 61. CANADA, EXPLORATION AND CAPITAL EXPENDITURES[1] IN THE MINING INDUSTRY BY TYPE OF MINING, 1985-87

		Capital						Repair			Total capital and repair	Outside or general exploration	Total, all expenditures
		Construction				Machinery and equipment	Total capital	Construction	Machinery and equipment	Total repair			
		On-property exploration	On-property development	Structures	Total								
							($ million)						
Metal Mines													
Gold	1985	40.8	196.1	175.5	412.4	92.3	504.7	19.0	84.5	103.5	608.2	48.3	656.5
	1986[p]	45.8	232.5	81.3	359.6	93.8	453.4	18.4	97.8	116.2	569.6	57.7	627.3
	1987[i]	56.1	222.6	113.1	391.8	93.9	485.7	19.6	113.5	133.1	618.8	55.8	674.6
Copper-gold-silver	1985	18.9	79.6	92.9	191.4	73.1	264.5	18.8	227.5	246.3	510.8	29.7	540.5
	1986[p]	25.1	76.0	67.4	168.5	47.6	216.1	13.9	215.2	229.1	445.2	11.4	456.6
	1987[i]	(4)	64.8	(4)	144.7	36.0	180.7	12.6	221.6	234.2	414.9	13.1	428.0
Silver-lead-zinc	1985	(4)	48.8	(4)	64.1	31.2	95.3	9.2	85.7	94.9	190.2	11.3	201.5
	1986[p]	6.3	24.8	8.1	39.2	17.6	56.8	8.5	80.1	88.6	145.4	16.3	161.7
	1987[i]	6.2	27.9	10.8	44.9	56.0	100.9	9.5	80.3	89.8	190.7	15.5	206.2
Iron	1985	(4)	87.8	(4)	93.7	19.3	113.0	9.1	192.3	201.4	314.4	(4)	(4)
	1986[p]	(4)	71.7	(4)	77.8	37.5	115.3	9.8	187.1	196.9	312.2	(4)	(4)
	1987[i]	(4)	56.4	(4)	67.6	18.1	85.7	9.7	175.2	184.9	270.6	(4)	(4)
Uranium	1985	7.6	102.9	14.8	125.3	34.5	159.8	13.9	110.9	124.8	284.6	17.5	302.1
	1986[p]	(4)	78.3	(4)	94.3	34.9	129.2	9.7	129.3	139.0	268.2	4.5	272.7
	1987[i]	(4)	86.1	(4)	102.9	43.5	146.4	9.4	119.1	128.5	274.9	4.9	279.8
Other metal[2] mining	1985	10.3	81.4	70.1	161.8	68.6	230.4	33.3	137.6	170.9	401.3	(4)	(4)
	1986[p]	7.0	77.6	31.4	116.0	68.8	184.8	22.4	113.3	135.7	320.5	(4)	(4)
	1987[i]	6.0	78.7	12.8	97.5	72.0	169.5	23.2	117.2	140.4	309.9	(4)	(4)
Total metal mining	1985	90.0	596.6	362.1	1 048.7	319.0	1 367.7	103.3	858.5	961.8	2 329.5	112.8	2 442.3
	1986[p]	99.0	560.9	195.5	855.4	300.2	1 155.6	82.7	822.8	905.5	2 061.1	95.5	2 156.6
	1987[i]	111.8	534.5	203.1	849.4	319.5	1 168.9	84.0	826.9	910.9	2 079.8	94.5	2 174.3
Nonmetal Mines													
Asbestos	1985	(4)	(4)	4.6	29.3	5.1	34.4	3.3	47.2	50.5	84.9	(4)	(4)
	1986[p]	(4)	28.0	(4)	32.8	2.3	35.1	2.0	38.4	40.4	75.5	-	75.5
	1987[i]	(4)	(4)	(4)	34.7	3.8	38.5	1.5	35.6	37.1	75.6	-	75.6
Coal	1985	5.1	285.1	78.2	368.4	102.7	471.1	20.5	281.8	302.3	773.4	20.1	793.5
	1986[p]	6.4	167.4	44.4	218.2	104.4	322.6	10.8	289.7	300.5	623.1	16.6	639.7
	1987[i]	5.4	190.6	14.8	210.8	115.2	326.0	10.0	295.6	305.6	631.6	9.7	641.3
Other nonmetal mining[3]	1985	(4)	(4)	147.8	175.9	242.3	418.2	15.5	200.5	216.0	634.2	(4)	(4)
	1986[p]	(4)	39.9	(4)	73.9	186.4	260.3	14.0	195.8	209.8	470.1	1.5	471.6
	1987[i]	(4)	(4)	(4)	43.9	153.3	197.2	14.5	208.7	223.2	420.4	2.0	422.4
Total nonmetal mining	1985	8.7	334.3	230.6	573.6	350.1	923.7	39.3	529.5	568.8	1 492.5	21.1	1 513.6
	1986[p]	11.0	235.3	78.6	324.9	293.1	618.0	26.8	523.9	550.7	1 168.7	18.1	1 186.8
	1987[i]	10.0	239.2	40.2	289.4	272.3	561.7	26.0	539.9	565.9	1 127.6	11.7	1 139.3
Metal and Nonmetal Exploration Companies	1985	1.4	0.9	2.5	4.8	3.4	8.2	1.2	7.9	9.1	17.3	352.6	369.9
	1986[p]	0.2	1.1	1.7	3.0	2.6	5.6	0.4	7.8	8.2	13.8	369.9	383.7
	1987[i]	0.7	1.0	1.0	2.7	10.2	12.9	0.3	7.8	8.1	21.0	477.0	498.0
Total mining	1985	100.1	931.8	595.3	1 627.1	672.5	2 299.6	143.8	1 375.9	1 519.7	3 819.3	488.8	4 308.1
	1986[p]	110.2	797.3	276.1	1 183.3	595.9	1 779.2	109.9	1 354.5	1 464.4	3 243.6	483.6	3 727.2
	1987[i]	122.6	774.7	244.3	1 141.5	602.0	1 743.5	110.3	1 374.6	1 484.9	3 228.4	583.2	3 811.6

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[1] Excludes expenditures in the petroleum and natural gas industries. [2] Includes nickel-copper mines, silver-cobalt mines and other metal mines.
[3] Includes gypsum mines, salt mines, potash mines, quarries, sand and gravel pits and other nonmetal mines. (4) Confidential, included in total.
[p] Preliminary; [i] Intentions; - Nil.

TABLE 62. CANADA, DIAMOND DRILLING IN THE MINING INDUSTRY BY MINING COMPANIES WITH OWN EQUIPMENT AND BY DRILLING CONTRACTORS, 1983-85

		1983			1984			1985		
		Exploration	Other	Total	Exploration	Other	Total	Exploration	Other	Total
						(metres)				
Metal mines										
Nickel-copper-zinc	Own equipment	173 155	3 046	176 201	202 223	308 471	510 694	228 851	-	228 851
	Contractors	263 209	73 335	336 544	319 842	-	319 842	246 731	-	246 731
	Total	436 364	76 381	512 745	522 065	308 471	830 536	475 582	-	475 582
Gold	Own equipment	40 381	2 240	42 621	38 223	1 062	39 285	51 906	5 612	57 518
	Contractors	263 513	46 084	309 597	362 358	4 417	366 775	349 405	22 642	372 047
	Total	303 894	48 324	352 218	400 581	5 479	406 060	401 311	28 254	429 565
Iron mines	Own equipment	-	-	-	-	178 684	178 684	-	203 876	203 876
	Contractors	728	-	728	660	-	660	5 295	-	5 295
	Total	728	-	728	660	178 684	179 344	5 295	203 876	209 171
Silver-lead-zinc	Own equipment	69 863	75 852	145 715	67 559	4 772	72 281	60 074	3 983	64 057
	Contractors	123 944	-	123 944	200 957	-	200 957	88 345	290	88 635
	Total	193 807	75 852	269 695	268 516	4 772	273 238	148 419	4 273	152 692
Uranium	Own equipment	40 984	-	40 984	47 675	-	47 675	41 659	-	41 659
	Contractors	34 453	-	34 453	23 716	-	23 716	12 827	-	12 827
	Total	75 437	-	75 437	71 391	-	71 391	54 486	-	54 486
Miscellaneous metal mining	Own equipment	-	-	-	2 000	-	2 000	-	-	-
	Contractors	21 496	-	21 496	28 926	-	28 926	22 707	400	23 107
	Total	21 496	-	21 496	30 926	-	30 926	22 707	400	23 107
Total metal mining	Own equipment	324 383	81 138	405 521	357 680	492 939	850 619	382 490	230 501	612 991
	Contractors	707 343	119 419	826 762	936 459	4 417	940 876	725 310	6 302	731 612
	Total	1 031 726	200 557	1 232 283	1 294 139	497 356	1 791 495	1 107 800	236 803	1 344 603
Nonmetal mines										
Other nonmetal mines	Own equipment	2 220	-	2 220	360	-	360	11 473	-	11 473
	Contractors	9 159	-	9 159	4 191	-	4 191	3 064	-	3 064
	Total	11 379	-	11 379	4 551	-	4 551	14 537	-	14 537
Asbestos	Own equipment	-	-	-	-	-	-	-	-	-
	Contractors	-	-	-	3 293	-	3 293	5 160	-	5 160
	Total	-	-	-	3 293	-	3 293	5 160	-	5 160
Gypsum	Own equipment	-	-	-	-	-	-	-	-	-
	Contractors	762	-	762	3 319	-	3 319	521	2 183	2 704
	Total	762	-	762	3 319	-	3 319	521	2 183	2 704
Total nonmetal mining	Own equipment	2 220	-	2 220	360	-	360	11 473	-	11 473
	Contractors	9 921	-	9 921	10 803	-	10 803	8 745	2 183	10 928
	Total	12 141	-	12 141	11 163	-	11 163	20 218	2 183	22 401
Total mining industry	Own equipment	326 603	81 138	407 741	358 040	492 939	850 979	393 963	230 501	624 464
	Contractors	717 264	119 419	836 683	947 262	4 417	951 679	734 055	8 485	742 540
	Total	1 043 867	200 557	1 244 424	1 305 302	497 356	1 802 658	1 128 018	238 986	1 367 004

- Nil.

TABLE 63. CANADA, ORE MINED AND ROCK QUARRIED IN THE MINING INDUSTRY, 1956-85

	Metals	Industrials[1]	Coal	Total
	(million tonnes)			
1956	70.2	66.2		136.4
1957	76.4	74.5		150.9
1958	71.4	71.2		142.6
1959	89.9	82.2		172.1
1960	92.1	88.7		180.8
1961	90.1	96.7		186.8
1962	103.6	103.8		207.4
1963	112.7	120.4		233.1
1964	128.0	134.1		262.1
1965	151.0	146.5		297.5
1966	147.6	171.8		319.4
1967	169.1	177.5		346.6
1968	186.9	172.7		359.6
1969	172.0	178.8		350.8
1970	213.0	179.1		392.1
1971	211.5	185.8		397.3
1972	206.0	189.7		395.7
1973	274.8	162.6		437.3
1974	278.7	178.8		457.6
1975	264.2	158.7		422.9
1976	296.5	167.1		463.6
1977	299.5	205.2	33.8	538.6
1978	248.1	205.5	36.3	489.8
1979	274.8	197.7	39.8	512.2
1980	290.1	190.3	43.9	524.3
1981	301.5	169.7	48.2	519.5
1982	238.4	119.1	53.0	410.4
1983	219.0	134.0	54.8	407.9
1984	246.4	164.0	71.2	481.6
1985	245.0	168.9	76.7	490.5

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[1] Includes nonmetallic mineral mining and all stone quarried, including stone used to make cement and lime. From 1977 onwards, coverage is the same as in Table 59.

TABLE 64. CANADA, TOTAL DIAMOND DRILLING, METAL DEPOSITS, 1956-85

	Gold Deposits	Copper-zinc and Nickel-copper Deposits	Silver-lead-zinc Deposits	Other Metal Bearing Deposits[1]	Total Metal Deposits
			(metres)		
1956	682 600	1 490 298	399 679	383 431	2 956 008
1957	706 273	1 098 490	323 704	287 364	2 415 831
1958	546 861	923 026	297 792	286 970	2 054 649
1959	558 160	1 110 664	282 088	383 471	2 334 383
1960	628 016	1 267 792	226 027	315 067	2 436 902
1961	503 741	1 128 091	255 101	221 079	2 199 452
1962	902 288	1 025 048	350 180	358 679	2 636 195
1963	529 958	977 257	288 204	148 703	1 944 122
1964	458 933	709 588	401 099	104 738	1 674 358
1965	440 020	779 536	331 294	275 917	1 826 727
1966	442 447	729 148	292 223	164 253	1 628 071
1967	391 347	947 955	230 182	120 350	1 689 834
1968	375 263	935 716	198 038	56 780	1 565 797
1969	274 410	923 452	197 670	109 592	1 505 124
1970	214 717	1 132 915	375 019	99 373	1 822 024
1971	193 291	1 089 103	308 798	83 851	1 675 043
1972	229 771	967 640	240 195	50 225	1 487 831
1973	243 708	713 134	185 946	57 730	1 200 518
1974	250 248	798 564	197 322	83 484	1 329 618
1975	216 158	532 991	184 203	97 971	1 031 323
1976	156 030	507 620	166 366	97 735	927 751
1977	175 643	515 780	213 279	124 329	1 029 031
1978	209 335	227 065	490 489	135 197	1 181 743
1979	198 955	437 562	131 032	150 018	917 567
1980	187 635	566 610	259 877	173 945	1 188 067
1981	306 197	675 712	478 754	170 369	1 631 032
1982	288 421	386 940	424 218	164 742	1 264 321
1983	352 218	512 745	269 659	97 661	1 232 283
1984	406 060	830 536	273 238	281 661	1 791 495
1985	429 565	475 582	152 692	286 764	1 344 603

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[1] Includes iron, titanium, uranium, molybdenum and other metal deposits.

TABLE 65. CANADA, EXPLORATION DIAMOND DRILLING, METAL DEPOSITS, 1956-85

	Mining Companies with Own Personnel and Equipment	Diamond Drill Contractors	Total
		(metres)	
1956	474 562	1 644 735	2 119 297
1957	358 300	1 233 323	1 591 623
1958	237 133	1 200 625	1 437 758
1959	239 786	1 367 061	1 606 847
1960	268 381	1 409 416	1 677 797
1961	302 696	1 337 173	1 639 869
1962	167 214	1 748 023	1 915 237
1963	361 180	1 169 292	1 530 472
1964	143 013	1 072 985	1 215 998
1965	209 002	1 176 996	1 385 998
1966	163 379	1 044 860	1 208 239
1967	93 164	1 123 137	1 216 301
1968	159 341	990 690	1 150 031
1969	135 311	1 072 328	1 207 639
1970	62 147	1 228 061	1 290 208
1971	86 838	1 053 330	1 140 168
1972	251 651	839 753	1 091 404
1973	321 333	742 899	1 064 232
1974	357 823	892 557	1 250 380
1975	346 770	618 161	964 931
1976	335 919	532 036	867 955
1977	327 241	638 327	965 568
1978	237 250	534 557	771 807
1979	311 221	571 721	882 942
1980	347 829	747 566	1 095 395
1981	460 687	917 566	1 378 253
1982	289 901	713 413	1 003 314
1983	324 383	707 343	1 031 726
1984	357 680	936 459	1 294 139
1985	382 490	725 310	1 107 800

TABLE 66. CANADA, DIAMOND DRILLING OTHER THAN FOR EXPLORATION, METAL DEPOSITS, 1956-85

	Mining Companies with Own Personnel and Equipment	Diamond Drill Contractors	Total
		(metres)	
1956	790 522	46 188	836 710
1957	524 724	156 060	680 784
1958	444 376	172 516	616 892
1959	488 783	238 753	727 536
1960	450 246	308 860	759 105
1961	384 432	175 149	559 581
1962	528 700	192 259	720 959
1963	388 228	25 422	413 650
1964	385 765	72 594	458 359
1965	393 947	46 822	440 769
1966	227 968	191 863	419 831
1967	186 463	287 071	473 534
1968	122 851	292 914	415 765
1969	87 552	209 933	297 485
1970	290 363	241 453	531 816
1971	295 966	238 910	534 876
1972	304 523	91 903	396 426
1973	77 162	59 124	136 286
1974	54 353	24 885	79 238
1975	31 917	34 475	66 392
1976	31 413	28 383	59 796
1977	24 303	39 160	63 463
1978	351 344	58 592	409 936
1979	4 090	30 535	34 625
1980	20 545	72 127	92 672
1981	200 898	51 881	252 779
1982	188 674	72 333	261 007
1983	81 138	119 419	200 557
1984	492 939	4 417	497 356
1985	230 501	6 302	236 803

Nonproducing companies excluded since 1964.

TABLE 67. CANADA, CRUDE MINERALS TRANSPORTED BY CANADIAN RAILWAYS, 1983-85

	1983	1984	1985
		(kilotonnes)	
Metallic minerals			
Iron ores and concentrates	30 281	35 269	39 197
Nickel-copper ores and concentrates	2 738	4 228	4 161
Alumina and bauxite	3 091	3 523	3 227
Copper ores and concentrates	1 488	1 495	1 467
Zinc ores and concentrates	1 571	1 693	1 452
Lead ores and concentrates	588	1 507	604
Metallic ores and concentrates, n.e.s.	73	41	73
Nickel ores and concentrates	97	-	-
Total metallic minerals	39 927	47 756	50 181
Nonmetallic minerals			
Potash (KCl)	9 239	10 937	9 891
Sulphur, n.e.s.	4 477	5 948	6 355
Gypsum	5 065	5 449	5 492
Limestone, n.e.s.	2 715	2 832	2 312
Phosphate rock	2 017	2 102	1 838
Sulphur, liquid	1 440	1 989	1 529
Salt, rock	941	819	650
Sand, industrial	816	927	879
Clay	534	607	633
Sodium carbonate	484	492	485
Sodium sulphate	496	440	386
Limestone, industrial	257	264	418
Sand, n.e.s.	263	319	321
Nepheline syenite	291	274	241
Nonmetallic minerals, n.e.s.	143	168	181
Salt, n.e.s.	112	102	101
Limestone, agricultural	59	94	85
Asbestos	120	99	81
Stone, n.e.s.	117	72	70
Peat and other mosses	19	27	22
Abrasives, natural	32	33	20
Barite	44	23	13
Silica	13	12	11
Total nonmetallic minerals	29 713	34 029	32 014
Mineral fuels			
Coal, bituminous	24 284	37 577	41 539
Coal, lignite	1 235	1 627	1 336
Coal, n.e.s.	70	85	54
Natural gas and other crude bituminous substances	11	28	37
Oil, crude	50	4	5
Total mineral fuels	25 650	39 321	42 971
Total crude minerals	95 290	121 106	125 166
Total revenue freight moved by Canadian railways	222 830	254 581	250 608
Percent crude minerals of total revenue freight	42.8	47.6	49.9

n.e.s. Not elsewhere specified; - Nil.

TABLE 68. CANADA, FABRICATED MINERAL PRODUCTS TRANSPORTED BY CANADIAN RAILWAYS, 1983-85

	1983	1984	1985
		(kilotonnes)	
Metallic mineral products			
Ferrous mineral products			
Iron and steel scrap	1 720	2 272	2 533
Sheets and strips, steel	657	1 022	1 072
Ingots, blooms, billets, slabs of iron and steel	1 300	1 064	907
Bars and rods, steel	642	705	715
Structural shapes and sheet piling, iron and steel	282	441	495
Plates, steel	413	430	426
Pipes and tubes, iron and steel	209	285	334
Castings and forgings, iron and steel	125	139	106
Rails and railway track material	108	94	59
Ferroalloys	45	48	43
Other primary iron and steel	20	27	29
Pig iron	50	65	22
Wire, iron or steel	12	12	6
Total ferrous mineral products	5 583	6 604	6 747
Nonferrous mineral products			
Aluminum and aluminum alloy fabricated material, n.e.s.	733	781	889
Zinc and alloys	484	504	536
Copper and alloys, n.e.s.	423	467	407
Aluminum paste, powder, pigs, ingots, shot	252	160	273
Other nonferrous base metals and alloys	13	177	179
Lead and alloys	146	149	170
Slag, dross, etc.	126	116	99
Nonferrous metal scrap	94	105	98
Copper matte and precipitates	5	526	4
Total nonferrous mineral products	2 276	2 985	2 655
Total metallic mineral products	7 859	9 589	9 402
Nonmetallic mineral products			
Fertilizers and fertilizer materials, n.e.s.	1 747	2 195	1 815
Portland cement, standard	1 589	1 409	1 687
Sulphuric acid	1 067	1 322	1 422
Gypsum basic products, n.e.s.	108	198	254
Nonmetallic mineral basic products, n.e.s.	268	271	224
Cement and concrete basic products, n.e.s.	245	188	164
Natural stone basic products, chiefly structural	193	202	160
Lime, hydrated and quick	156	155	139
Dolomite and magnesite, calcined	55	78	77
Glass basic products	72	57	47
Fire brick and similar shapes	32	46	28
Bricks and tiles, clay	20	8	12
Asbestos and asbestos-cement basic products	4	3	9
Refractories, n.e.s.	12	10	5
Plaster	11	5	3
Total nonmetallic mineral products	6 644	6 147	6 046
Mineral fuel products			
Refined and manufactured gases, fuel type	2 753	2 711	2 825
Diesel fuel	2 053	1 967	1 690
Gasoline	1 332	1 273	1 077
Other petroleum and coal products	758	694	701
Fuel oil, n.e.s.	829	843	680
Coke, n.e.s.	606	663	672
Petroleum coke	467	516	521
Asphalts and road oils	183	306	374
Lubricating oils and greases	330	372	337
Total mineral fuel products	9 311	9 345	8 877
Total fabricated mineral products	23 814	25 081	24 325
Total revenue freight moved by Canadian railways	222 830	254 581	250 608
Fabricated mineral products as a percentage of total revenue freight	10.7	9.9	9.7

n.e.s. Not elsewhere specified.

TABLE 69. CANADA, CRUDE AND FABRICATED MINERALS TRANSPORTED BY CANADIAN RAILWAYS, 1956-85

	Total Revenue Freight	Total Crude Minerals	Total Fabricated Minerals	Total Crude and Fabricated Minerals	Crude and Fabricated Minerals as Percent of Revenue Freight
1956	172.0	68.7	21.8	90.5	52.6
1957	157.9	64.2	17.1	81.3	51.5
1958	139.2	52.4	15.2	67.6	48.6
1959	150.6	62.8	15.3	78.1	52.9
1960	142.8	57.1	14.5	71.6	50.1
1961	138.9	54.1	13.6	67.7	48.7
1962	146.0	60.3	13.8	74.1	50.8
1963	154.6	62.9	15.5	78.3	50.6
1964	180.0	74.6	15.9	90.5	50.3
1965	186.2	80.9	17.3	98.2	52.7
1966	194.5	80.6	17.8	98.4	50.6
1967	190.0	81.2	17.7	98.9	52.1
1968	195.4	86.7	18.8	105.5	54.0
1969	189.0	81.9	27.6	109.5	57.9
1970	211.6	97.5	28.4	127.9	60.4
1971	214.5	95.6	27.4	123.0	57.3
1972	215.8	89.4	27.6	117.0	54.2
1973	241.2	113.1	29.1	142.2	59.0
1974	246.3	115.3	30.9	146.2	59.4
1975	226.0	110.6	26.6	137.2	60.7
1976	238.5	116.6	25.5	142.1	59.6
1977	247.2	121.1	25.7	146.8	59.4
1978	238.8	107.7	26.2	133.9	45.1
1979	257.9	127.2	26.6	153.8	59.6
1980	254.4	124.8	24.6	149.4	58.8
1981	246.6	120.7	26.4	147.1	59.7
1982	212.5	95.7	21.0	116.7	54.9
1983	222.8	95.3	23.8	119.1	53.5
1984	254.6	121.1	25.1	146.2	57.4
1985	250.6	125.2	24.3	149.5	59.7

TABLE 70. CANADA, CRUDE AND FABRICATED MINERALS TRANSPORTED THROUGH THE ST. LAWRENCE SEAWAY[1], 1984-86

	Montreal - Lake Ontario Section			Welland Canal Section		
	1984	1985	1986	1984	1985	1986
	(tonnes)					
Crude minerals						
Iron ore	11 421 521	8 679 210	8 026 080	10 088 727	6 788 799	5 839 484
Coal	452 898	607 108	609 619	6 603 148	5 807 694	5 775 521
Salt	898 931	657 494	874 520	1 725 967	1 521 180	1 882 656
Other crude minerals	842 988	1 099 291	1 201 223	694 588	732 510	851 262
Stone, ground or crushed	117 233	258 745	271 945	537 585	815 313	1 005 726
Aluminum ores and concentrates	185 500	200 890	196 830	185 452	198 890	175 508
Clay and bentonite	157 206	162 410	161 366	157 206	162 410	161 366
Sand and gravel	6 992	1	16 009	318 736	176 291	82 436
Phosphate rock	5 484	23 522	28 730	-	-	-
Stone, rough	206	302	203	206	302	182
Total crude minerals	14 008 959	11 688 973	11 386 525	20 311 615	16 203 389	15 774 141
Fabricated mineral products						
Iron and steel, manufactured	3 566 220	2 798 848	2 922 806	3 182 737	2 407 431	2 385 475
Coke	793 112	802 266	867 412	858 598	921 887	993 268
Scrap iron and steel	303 619	635 622	740 276	325 725	753 927	782 966
Fuel oil	745 378	558 770	641 156	678 186	628 613	603 625
Iron and steel, bars, rods, slabs	861 123	791 144	615 469	769 358	675 205	455 565
Cement	10	175 111	152 616	531 399	309 120	347 060
Gasoline	237 388	111 419	206 107	251 160	141 601	186 564
Other petroleum products	134 353	84 179	110 263	134 139	76 295	114 252
Pig iron	243 817	103 610	96 925	218 538	89 263	71 730
Tar, pitch and creosote	51 533	35 892	39 222	74 189	69 324	54 810
Lubricating oils and greases	17 430	41 964	25 850	17 106	41 962	15 290
Iron and steel, nails, wire	25 888	13 229	10 527	10 822	12 287	9 030
Total fabricated minerals	6 979 871	6 162 054	6 428 629	7 051 957	6 126 915	6 019 635
Total crude and fabricated minerals	20 988 830	17 841 027	17 815 154	27 363 572	22 330 304	21 793 776
Total, all products	47 505 456	37 321 698	37 581 808	53 916 858	41 851 760	41 612 770
Crude and fabricated minerals as a percent of total	44.2	47.8	47.4	50.8	53.4	52.3

[1] Total cargo transported regardless of travel direction.
- Nil.

TABLE 71. CANADA, CRUDE AND FABRICATED MINERALS TRANSPORTED THROUGH THE ST. LAWRENCE SEAWAY[1], 1957-86

	Montreal - Lake Ontario Section				Welland Canal Section			
	Total All Products	Total Crude Minerals	Total Fabricated Minerals	Crude and Fabricated Minerals as Percent of All Products	Total All Products	Total Crude Minerals	Total Fabricated Minerals	Crude and Fabricated Minerals as Percent of All Products
	(kilotonnes)				(kilotonnes)			
1957	11 059	4 439	1 392	52.7	20 296	11 305	2 421	67.6
1958	10 670	3 064	1 020	38.3	19 300	8 994	2 107	57.5
1959	19 252	7 725	2 197	51.5	24 953	12 117	2 246	57.6
1960	18 460	5 760	2 904	46.9	26 563	12 679	2 606	57.5
1961	21 212	6 706	2 358	42.7	28 490	12 599	2 378	52.7
1962	23 271	7 531	2 522	43.2	32 215	15 625	2 342	55.8
1963	28 198	9 507	2 804	43.7	37 490	18 094	2 524	55.0
1964	35 701	13 127	3 558	46.7	46 644	23 489	3 095	57.0
1965	39 352	13 788	6 024	50.3	48 477	23 555	4 933	58.8
1966	44 538	16 376	6 340	51.0	53 648	25 712	5 329	57.8
1967	39 918	17 800	6 430	60.7	47 945	26 010	5 459	65.6
1968	43 496	19 312	8 425	63.8	52 712	29 075	7 587	69.6
1969	37 256	12 682	8 263	56.2	48 601	25 090	6 715	65.4
1970	46 445	15 554	8 932	52.7	57 121	27 233	7 156	60.2
1971	48 069	14 204	9 263	48.8	57 205	23 903	7 914	55.6
1972	48 607	13 425	9 837	47.9	58 146	24 808	7 701	55.9
1973	52 285	17 111	9 639	51.1	60 958	26 907	7 718	56.8
1974	40 049	16 137	7 018	57.8	47 500	23 952	5 437	61.9
1975	43 554	15 698	6 071	50.0	53 387	26 100	5 129	58.5
1976	49 348	20 884	7 181	56.9	58 368	29 914	6 323	62.1
1977	57 456	23 008	9 918	57.3	65 079	30 459	8 933	60.5
1978	51 658	15 057	8 558	45.7	59 576	22 700	7 759	51.1
1979	50 187	16 408	8 104	48.8	60 023	24 851	7 940	54.6
1980	42 142	12 248	6 009	43.3	54 074	20 487	5 405	47.9
1981	45 876	15 453	5 711	46.1	53 389	22 132	5 529	51.8
1982	38 841	9 146	4 997	36.4	44 474	15 057	4 333	45.9
1983	45 061	12 443	5 422	39.6	50 145	17 412	5 618	45.9
1984	47 505	14 009	6 980	44.2	53 917	20 312	7 056	50.8
1985	37 322	11 689	6 152	47.8	41 852	16 203	6 127	53.4
1986	37 582	11 387	6 429	47.4	41 613	15 774	6 020	52.3

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[1] Total cargo transported regardless of travel direction.

TABLE 72. CANADA, CRUDE MINERALS LOADED AND UNLOADED IN COASTWISE SHIPPING, 1986P

	Loaded				Unloaded			
	Atlantic	Great Lakes	Pacific	Total	Atlantic	Great Lakes	Pacific	Total
				(tonnes)				
Metallic minerals								
Iron ore and concentrates	4 915 096	609 595	1 179	5 525 870	741 143	4 783 548	1 179	5 525 870
Titanium ore	2 180 709	-	-	2 180 709	2 180 709	-	-	2 180 709
Zinc ore and concentrates	-	-	24 580	24 580	-	-	24 580	24 580
Metallic ores and concentrates, n.e.s.	1 116	-	272	1 388	1 116	-	272	1 388
Total metals	7 096 921	609 595	26 031	7 732 547	2 922 968	4 783 548	26 031	7 732 547
Nonmetallic minerals								
Limestone	1 358	3 024 332	1 502 093	4 527 783	1 358	3 024 332	1 502 093	4 527 783
Salt	1 428 598	1 421 801	-	2 850 399	2 013 122	837 277	-	2 850 399
Sand and gravel	256 698	29 398	882 593	1 168 689	256 698	29 398	882 593	1 168 689
Gypsum	748 313	-	29 201	777 514	535 718	212 595	29 201	777 514
Stone, crude, n.e.s.	450	137 596	15 651	153 697	450	137 596	15 651	153 697
Potash	913	102 244	-	103 157	23 139	80 018	-	103 157
Quartz-silica	47 261	-	862	48 123	-	47 261	862	48 123
Sulphur crude and refined	5 773	-	-	5 773	5 773	-	-	5 773
Crude nonmetallic minerals, n.e.s.	3 039	-	45	3 084	3 039	-	45	3 084
Total nonmetals	2 492 403	4 715 371	2 430 445	9 638 219	2 839 297	4 368 477	2 430 445	9 638 219
Mineral fuels								
Coal and peat for fuel	141 906	2 037 154	95 130	2 274 190	198 206	2 037 154	38 830	2 274 190
Petroleum, crude	256 228	-	-	256 228	256 228	-	-	256 228
Total mineral fuels	398 134	2 037 154	95 130	2 530 418	454 434	2 037 154	38 830	2 530 418
Total crude minerals	9 987 458	7 362 120	2 551 606	19 901 184	6 216 699	11 189 179	2 495 306	19 901 184
Total all commodities	18 150 300	22 598 009	19 766 842	60 506 152	25 200 354	15 634 250	19 671 548	60 506 152
Crude minerals as a percent of all commodities	55.0	32.6	12.9	32.9	24.7	71.6	12.7	32.9

P Preliminary; - Nil; n.e.s. Not elsewhere specified.

TABLE 73. CANADA, FABRICATED MINERALS LOADED AND UNLOADED IN COASTWISE SHIPPING, 1986P

	Loaded				Unloaded			
	Atlantic	Great Lakes	Pacific	Total	Atlantic	Great Lakes	Pacific	Total
				(tonnes)				
Metallic mineral products								
Ferrous mineral products								
Structual shapes, iron and steel	3 242	173 850	46 705	223 797	3 242	173 850	46 705	223 797
Plates and sheets, steel	787	38 030	2 722	41 538	787	38 030	2 722	41 538
Primary iron, steel	25 191	20	1 134	26 345	-	25 211	1 134	26 345
Castings and forgings, steel	790	-	9 072	9 862	790	-	9 072	9 862
Pipes and tubes, iron and steel	536	-	2 903	3 439	536	-	2 903	3 439
Wire, iron and steel	873	-	-	873	873	-	-	873
Bars and rods, steel	699	-	-	699	699	-	-	699
Rails and railway track material	26	149	-	175	26	149	-	175
Aluminum and aluminum products	116 802	-	-	116 802	116 802	-	-	116 802
Total metallic mineral products	148 946	212 049	62 536	423 530	123 755	237 240	62 536	423 530
Nonmetallic mineral products								
Cement	34 348	722 346	77 552	834 247	50 922	705 773	77 552	834 247
Sulphuric acid	10 457	-	19 278	29 735	10 457	-	19 278	29 735
Bricks, tiles and pipes, clay	1 162	128	2 000	3 290	1 162	128	2 000	3 290
Fertilizers and fertilizer material, n.e.s.	8 300	-	-	8 300	2 329	5 971	-	8 300
Other nonmetallic mineral products	2 968	27	-	2 995	2 968	27	-	2 995
Cement basic products	107	-	1 077	1 184	107	-	1 077	1 184
Glass basic products	158	-	-	158	158	-	-	158
Asbestos basic products	150	-	-	150	150	-	-	150
Total nonmetallic mineral products	57 650	722 501	99 907	880 059	68 253	711 899	99 907	880 059
Mineral fuel products								
Fuel oil	3 903 913	803 875	1 123 875	5 831 663	4 125 273	607 025	1 099 366	5 831 663
Gasoline	2 062 889	388 399	555 435	3 006 724	2 134 870	335 745	536 109	3 006 724
Asphalts and road oils	31 353	39 002	-	70 355	21 728	48 627	-	70 355
Petroleum coke	16 000	6 348	-	22 348	22 348	-	-	22 348
Lubricating oils and greases	4 469	-	107	4 576	862	3 607	107	4 576
Other petroleum and coal products	15 591	9 590	-	25 181	11 798	13 383	-	25 181
Total mineral fuel products	6 034 215	1 247 214	1 679 417	8 960 847	6 316 879	1 008 387	1 635 582	8 960 847
Total fabricated mineral products	6 240 811	2 181 764	1 841 860	10 264 436	6 508 887	1 957 526	1 798 025	10 264 436
Total all commodities	18 150 300	22 589 009	19 766 842	60 506 152	25 200 354	15 634 250	19 671 548	60 506 152
Fabricated mineral products as a percent of all commodities	34.4	9.7	9.3	17.0	25.8	12.5	9.1	17.0

P Preliminary; - Nil; n.e.s. Not elsewhere specified.

TABLE 74. CANADA, CRUDE AND FABRICATED MINERALS LOADED AT CANADIAN PORTS IN COASTWISE SHIPPING; 1957-86

	Total All Commodities	Total Crude Minerals	Total Fabricated Minerals	Crude and Fabricated Minerals as Percent of All Products
		(kilotonnes)		
1957	34 354	8 696	7 832	48.1
1958	34 808	7 673	7 258	42.9
1959	36 494	9 984	7 819	48.8
1960	37 058	8 786	8 229	45.9
1961	41 861	9 527	8 857	43.9
1962	39 763	8 361	9 768	45.6
1963	40 328	7 998	9 942	44.5
1964	47 171	8 522	11 194	41.8
1965	48 200	9 183	11 766	43.5
1966	55 122	10 155	12 653	41.4
1967	49 799	11 509	12 207	47.6
1968	50 921	13 698	13 245	52.9
1969	51 890	12 746	14 181	51.9
1970	57 301	14 415	14 818	51.0
1971	55 128	14 783	15 374	54.7
1972	55 326	14 197	15 290	53.3
1973	55 314	16 573	15 615	58.2
1974	53 633	11 723	16 575	52.8
1975	54 373	15 687	17 510	61.1
1976	53 882	15 924	16 208	59.6
1977	58 309	18 131	17 435	61.0
1978	60 668	18 318	16 619	57.6
1979	79 950	22 130	17 486	50.2
1980	82 761	22 947	17 134	48.4
1981	71 271	17 849	16 669	48.4
1982	65 881	16 473	13 214	45.1
1983	67 598	21 248	12 025	49.2
1984	68 698	22 798	11 909	50.5
1985	61 717	19 867	10 291	48.9
1986P	60 506	19 901	10 264	49.9

P Preliminary.

TABLE 75. CANADA, CRUDE MINERALS LOADED AND UNLOADED AT CANADIAN PORTS IN INTERNATIONAL SHIPPING TRADE, 1984-86

	1984		1985		1986P	
	Loaded	Unloaded	Loaded	Unloaded	Loaded	Unloaded
	(tonnes)					
Metallic minerals						
Iron ore and concentrates	31 005 195	5 565 570	32 669 302	6 457 303	30 321 884	6 140 184
Copper ores and concentrates	1 129 159	102 695	1 179 258	224 479	1 344 875	92 763
Titanium ore	743 771	14 204	1 032 233	3 782	(2)	(2)
Zinc ore and concentrates	821 896	299	655 418	160	645 143	403
Nickel ore and concentrates	120 390	8 730	113 252	6 053	(1)	(1)
Lead ore and concentrates	65 567	7 551	110 289	1 916	85 068	11 446
Other nonferrous ores, concentrates and metal scrap, n.e.s.	87 948	26 125	108 701	67 437	1 403 697	346 250
Alumina, bauxite ore	42 803	3 655 040	45 877	3 320 373	27 136	3 825 085
Manganese ore	-	188 864	2 522	182 024	(2)	(2)
Total metals	34 016 729	9 569 078	35 916 852	10 263 527	33 827 803	10 416 131
Nonmetallic minerals						
Gypsum	5 556 660	126 685	5 806 971	77 902	5 781 274	177 148
Sulphur	5 848 191	3	5 371 105	-	4 743 012	42 001
Potash (KCl)	5 987 217	1 544	4 759 062	79 292	5 733 732	59 934
Salt	2 673 379	980 128	2 053 809	1 253 350	2 222 807	1 232 261
Limestone	1 508 547	1 619 486	1 090 691	861 734	1 114 655	1 208 292
Stone, crushed	91 946	20	875 543	991 178	(3)	(3)
Asbestos	552 180	559	506 633	727	189 219	1 241
Dolomite	631 129	12 914	377 041	17 674	(3)	(3)
Sand and gravel	42 389	1 548 098	249 850	1 489 944	295 463	1 321 022
Stone, crude, n.e.s.	35 953	35 770	95 879	91 446	(3)	(3)
Crude, nonmetallic minerals, n.e.s.	149 080	20 378	111 735	24 213	1 248 417	1 391 392
Phosphate rock	-	1 836 376	2 200	1 557 629	25 590	1 602 018
Clay materials, n.e.s.	745	7 216	1 236	1 541	716 438	345 832
Bentonite	26	152 262	165	176 349	(4)	(4)
China clay	-	21 179	54	15 379	(4)	(4)
Fluorspar	-	119 602	-	114 081	(3)	(3)
Barite	-	10 668	-	8 012	(3)	(3)
Total nonmetals	23 077 442	6 492 888	21 301 974	6 760 451	22 370 607	7 381 141
Mineral fuels						
Coal, bituminous	25 395 206	18 577 598	25 964 493	15 168 031	25 453 138	13 557 832
Petroleum, crude	230 035	8 310 602	694 576	9 693 288	1 306 998	12 408 485
Fuels, n.e.s.	32 970	109	343	2 565	3 401	37
Total fuels	25 658 211	26 888 309	26 659 412	24 863 884	26 763 537	25 966 354
Total crude minerals	82 752 382	42 950 275	83 878 238	41 887 862	82 961 947	43 763 626
Total all commodities	145 322 054	60 072 623	143 420 769	60 668 828	143 245 953	61 791 872
Crude minerals as a percent of all commodities	56.9	71.5	58.5	69.0	57.9	70.8

(1) Included with "Copper ores and concentrates". (2) Included with "Other nonferrous ores concentrates and metal scrap n.e.s.". (3) Included with "Crude nonmetallic minerals, n.e.s.". (4) Included with "Clay materials, n.e.s.".
- Nil; n.e.s. Not elsewhere specified; P Preliminary.

TABLE 76. CANADA, FABRICATED MINERAL PRODUCTS LOADED AND UNLOADED AT CANADIAN PORTS IN INTERNATIONAL SHIPPING TRADE, 1984-86

	1984		1985		1986P	
	Loaded	Unloaded	Loaded	Unloaded	Loaded	Unloaded
			(tonnes)			
Metallic products						
Iron, pig	341 316	114 726	425 065	109 793	(1)	(1)
Iron and steel, other					982 533	1 816 062
plates and sheets	211 081	472 314	285 156	543 381	(1)	(1)
bars and rods	46 229	280 668	45 606	291 397	(1)	(1)
castings and forgings	16 004	141 290	43 478	129 390	(1)	(1)
rails and track material	56 903	22 461	29 946	62 771	(1)	(1)
pipes and tubes	13 312	213 191	28 105	316 062	(1)	(1)
wire and rope	19 334	200 094	14 141	176 398	(1)	(1)
structural shapes	33 317	137 938	9 267	132 351	(1)	(1)
Aluminum	299 463	109 309	446 744	98 430	(2)	(2)
Iron and steel, primary	402 526	2 960	561 992	2 339	(1)	(1)
Copper and alloys	189 132	61 686	176 556	45 850	(2)	(2)
Zinc and alloys	144 875	14 105	124 582	2 692	(2)	(2)
Nickel and alloys	51 337	37 775	45 156	33 752	(2)	(2)
Ferroalloys	35 958	27 405	45 026	39 117	(2)	(2)
Lead and alloys	19 773	3 594	21 844	801	(2)	(2)
Nonferrous metals, n.e.s.	6 310	24 374	8 193	32 995	716 447	174 269
Total metals	1 886 870	1 863 890	2 310 857	2 017 519	1 698 980	1 990 331
Nonmetallic products						
Cement	1 257 406	1 645	1 051 549	69 216	1 844 287	374 271
Cement basic products	282 120	8 242	534 736	81 305	(3)	(3)
Fertilisers, n.e.s.	566 091	365 746	224 809	200 035	(4)	(4)
Sulphuric acid	264 567	75	188 554	669 358	(4)	(4)
Nonmetallic mineral basic products	61 147	76 918	26 383	365 818	130 378	352 207
Building blocks, n.e.s.	17 216	148 009	17 471	186 522	(4)	(4)
Glass basic products	17 490	26 520	8 698	46 786	(4)	(4)
Asbestos basic products	6 367	788	1 972	630	(4)	(4)
Total nonmetals	2 472 404	627 943	2 054 172	1 619 670	1 974 665	726 478
Mineral fuel products						
Fuel oil	2 108 901	3 583 063	2 876 948	2 887 106	2 907 111	689 495
Gasoline	827 837	397 768	1 551 714	793 972	1 324 261	3 368 231
Coke	415 309	1 015 868	1 202 386	1 169 141	594 025	1 224 264
Petroleum and coal products, n.e.s.	211 737	58 759	790 650	154 065	404 956	291 282
Asphalts, road oils	31 904	58 749	12 777	58 778	(5)	(5)
Lubricating oils and greases	18 247	25 182	8 592	22 806	(5)	(5)
Coal tar, pitch	12 459	56 574	5 978	77 134	(5)	(5)
Total fuels	3 626 394	5 195 963	6 449 045	5 163 002	5 230 353	5 573 272
Total fabricated mineral products	7 985 668	7 687 796	10 814 074	8 800 191	8 903 998	8 290 081
Total all commodities	145 322 054	60 072 623	143 420 769	60 668 828	143 245 953	61 791 872
Fabricated mineral products as a percent of all commodities	5.5	12.8	7.5	14.5	6.2	13.4

(1) Included with "Iron and steel, other". (2) Included with "Nonferrous metals, n.e.s.". (3) Included with "Cement". (4) Included with "Nonmetallic mineral basic products". (5) Included with "Petroleum and coal products, n.e.s.".
P Preliminary; n.e.s. Not elsewhere specified.

TABLE 77. CANADA, CRUDE AND FABRICATED MINERALS LOADED AT CANADIAN PORTS IN INTERNATIONAL SHIPPING TRADE, 1957-86

	Total All Commodities	Total Crude Minerals	Total Fabricated Minerals	Crude and Fabricated Minerals as Percent of All Products
		(kilotonnes)		
1957	44 539	24 210	2 588	60.2
1958	36 559	16 602	1 642	49.9
1959	45 772	25 789	1 619	59.9
1960	45 872	24 671	2 039	58.2
1961	48 771	23 241	2 133	52.0
1962	54 676	30 446	2 296	59.9
1963	62 031	32 214	2 503	56.0
1964	75 760	42 087	2 602	59.0
1965	74 521	41 338	2 746	59.2
1966	76 192	41 374	3 350	58.7
1967	72 598	42 704	3 701	63.9
1968	78 663	48 680	2 960	65.6
1969	70 432	42 442	3 456	65.1
1970	95 807	55 849	4 965	63.5
1971	95 887	53 245	5 022	60.7
1972	98 988	51 912	9 091	61.6
1973	112 434	64 195	10 103	66.1
1974	106 110	64 093	9 041	68.9
1975	102 444	61 970	7 495	67.8
1976	114 815	71 527	6 108	67.6
1977	119 770	70 257	5 979	63.7
1978	116 522	62 291	7 556	59.9
1979	134 639	79 685	8 901	65.8
1980	138 161	67 898	11 770	57.7
1981	145 445	83 007	9 022	63.3
1982	125 282	65 594	7 115	58.1
1983	129 490	67 152	6 197	56.7
1984	145 322	82 752	7 986	62.4
1985	143 420	83 878	10 814	66.0
1986P	143 246	82 962	8 904	64.1

P Preliminary.

TABLE 78. CANADA, FINANCIAL STATISTICS OF CORPORATIONS IN THE MINING INDUSTRY[1] BY DEGREE OF NON-RESIDENT OWNERSHIP, 1984

	Corporations		Assets		Equity		Sales		Profits		Taxable Income	
	(number)	(%)	($ million)	(%)	($ million)	(%)	($ million)	(%)	($ million)	(%)	($ million)	(%)
Metal mines												
Reporting corporations												
Canadian												
Private sector	135	76.2	17 602	68.4	9 056	77.8	6 472	64.2	301	--	142	62.1
Government	5	2.8	2 039	7.9	-158	--	598	5.9	-645	--	-	-
Foreign	37	20.9	6 091	23.7	2 733	23.5	3 015	29.9	168	--	87	37.9
Total, all corporations	177	100.0	25 732	100.0	11 631	100.0	10 085	100.0	-176	100.0	229	100.0
Mineral fuels												
Reporting corporations												
Canadian												
Private sector	1 845	90.3	44 102	58.9	17 392	54.8	11 602	38.5	2 978	29.9	1 033	16.0
Government	9	0.4	1 480	2.0	843	2.7	433	1.4	74	0.7	-	-
Foreign	187	9.2	29 270	39.1	13 509	42.6	18 123	60.1	6 899	69.3	5 415	84.0
Total, all corporations	2 041	100.0	74 851	100.0	31 743	100.0	30 158	100.0	9 950	100.0	6 447	100.0
Other mining (including mining services)												
Reporting corporations												
Canadian												
Private sector	4 515	96.2	6 698	49.9	3 103	56.3	3 117	58.4	-63	32.3	183	41.0
Government	14	0.3	2 028	15.1	464	8.4	486	9.1	-46	23.6	1	0.1
Foreign	165	3.5	4 696	35.0	1 946	35.3	1 731	32.5	-86	44.1	263	58.9
Total, all corporations	4 694	100.0	13 422	100.0	5 513	100.0	5 334	100.0	-195	100.0	447	100.0
Total mining												
Reporting corporations												
Canadian												
Private sector	6 495	94.0	68 402	60.0	29 551	60.4	21 190	46.5	3 216	33.5	1 359	19.1
Government	28	0.4	5 547	4.9	1 148	2.4	1 517	3.3	-618	--	-	--
Foreign	389	5.6	40 057	35.1	18 188	37.2	22 869	50.2	6 981	72.9	5 765	80.9
Total, all corporations	6 912	100.0	114 006	100.0	48 887	100.0	45 576	100.0	9 579	100.0	7 124	100.0

Note: Footnotes for the following table also apply to this one. Figures may not add up to totals due to rounding.

[1] Cement, lime and clay products (domestic clay) are included in mineral manufacturing.

- Nil; -- Not applicable.

TABLE 79. CANADA, FINANCIAL STATISTICS OF CORPORATIONS IN THE MINERAL MANUFACTURING INDUSTRIES[1] BY DEGREE OF NON-RESIDENT OWNERSHIP, 1984

	Corporations[2]		Assets[3]		Equity[4]		Sales[5]		Profits[6]		Taxable Income[7]	
	(number)	(%)	($ million)	(%)	($ million)	(%)	($ million)	(%)	($ million)	(%)	($ million)	(%)
Primary metal products												
Reporting corporations[2]												
Canadian												
Private sector	367	89.7	x	--	x	--	x	--	x	--	x	--
Government	2	0.5	x	--	x	--	x	--	x	--	x	--
Foreign	40	9.8	2 770	17.7	1 084	16.6	2 150	16.2	161	28.1	85	12.7
Total, all corporations	409	100.0	15 611	100.0	6 519	100.0	13 298	100.0	572	100.0	695	100.0
Nonmetallic mineral products												
Reporting corporations[2]												
Canadian												
Private sector	1 434	95.3	x	--	x	--	x	--	x	--	x	--
Government	4	0.3	x	--	x	--	x	--	x	--	x	--
Foreign	66	4.4	4 867	69.6	2 765	77.6	2 986	53.2	317	66.4	189	52.5
Total, all corporations	1 504	100.0	6 989	100.0	3 564	100.0	5 614	100.0	478	100.0	359	100.0
Petroleum and coal products												
Reporting corporations[2]												
Canadian												
Private sector	91	80.5	x	--	x	--	x	--	x	--	x	--
Government	3	2.7	x	--	x	--	x	--	x	--	x	--
Foreign	19	16.8	20 157	59.4	10 938	60.0	25 542	71.0	1 762	64.9	286	52.4
Total, all corporations	113	100.0	33 959	100.0	18 226	100.0	35 975	100.0	2 715	100.0	545	100.0
Total mineral manufacturing industries												
Reporting corporations[2]												
Canadian												
Private sector	1 892	93.4	x	--	x	--	x	--	x	--	x	--
Government	9	0.4	x	--	x	--	x	--	x	--	x	--
Foreign	125	6.2	27 794	49.1	14 787	52.2	30 678	55.9	2 240	62.1	560	41.8
Total, all corporations	2 026	100.0	56 559	100.0	28 309	100.0	54 887	100.0	3 604	100.0	1 340	100.0

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[1] Includes cement, lime, and clay products (domestic clay). [2] Corporations reporting under the Corporations and Labour Unions Returns Act. A corporation is considered to be foreign controlled if 50 percent or more of its voting rights are known to be held outside Canada, and/or by one or more Canadian corporations which are, in turn, foreign controlled. Each corporation is classified according to the percentage of its voting rights which are owned by non-residents, either directly or through other Canadian corporations, and the whole of the corporation is assigned to this particular degree of foreign ownership. [3] Included are cash, marketable securities, accounts receivable, inventories, fixed assets, investments in affiliated corporations and other assets. The amounts tabulated are those shown on the balance sheets of corporations after deducting allowances for doubtful accounts, amortization, depletion and depreciation. [4] Equity represents the shareholders' interest in the net assets of the corporation and includes the total amount of all issued and paid-up share capital, earnings retained in the business and other surplus accounts such as contributed and capital surplus. [5] For nonfinancial corporations, sales are gross revenues from nonfinancial operations. For financial corporations, sales include income from financial as well as nonfinancial sources. [6] The net earnings from operations, investment income and net capital gains. Profits are tabulated after deducting allowances for amortization, depletion and depreciation, but before income tax provisions or declaration of dividends. [7] Taxable income figures are as reported by corporations prior to assessment by the Department of National Revenue. They include earnings in the reference year after the deduction of applicable losses of other years.

-- Not applicable; x Confidential.

TABLE 80. CANADA, FINANCIAL STATISTICS OF CORPORATIONS IN NONFINANCIAL INDUSTRIES BY MAJOR INDUSTRY GROUP AND BY CONTROL, 1983 AND 1984

	Agriculture, Forestry, Fishing and Trapping		Mines, Quarries and Oil Wells		Manufacturing		Construction		Transportation, Communication and Other Utilities		Trade		Services		Total	
	1983	1984P	1983	1984P	1983	1984P	1983	1984P	1983	1984P	1983	1984P	1983	1984P	1983	1984P
								(number)								
Corporations																
Canadian control																
Private sector	20 601	22 279	5 630	6 495	34 552	37 918	55 010	59 429	20 978	23 055	117 482	128 535	101 740	113 094	355 996	340 803
Government	4	5	26	28	52	53	1	1	75	73	32	36	33	28	223	226
Foreign control	95	82	431	389	1 890	1 764	166	151	269	243	1 663	1 528	615	564	5 128	4 721
Total corporations	20 700	22 366	6 087	6 912	36 494	39 735	55 177	59 581	21 322	23 371	119 177	130 099	102 388	113 686	361 345	395 750
								($ million)								
Assets																
Canadian control																
Private sector	x	x	63 597	68 402	86 995	94 886	x	x	58 463	64 329	68 247	77 832	33 166	36 929	341 321	373 642
Government	x	x	5 316	5 547	10 208	12 773	x	x	89 784	98 305	9 232	10 459	2 469	2 565	117 019	129 765
Foreign control	395	401	37 545	40 057	11 801	13 000	2 152	2 120	5 387	5 625	17 528	19 431	6 295	7 208	147 388	160 354
Total corporations	11 184	12 242	106 459	114 006	175 363	193 171	22 154	21 160	153 634	168 260	95 007	107 722	41 928	46 702	605 728	663 762
Equity																
Canadian control																
Private sector	x	x	26 351	29 551	31 352	35 067	x	x	21 692	24 012	19 789	23 560	7 679	8 960	114 522	129 572
Government	x	x	1 839	1 148	1 250	5 241	x	x	18 240	20 161	4 386	5 013	246	283	25 968	31 857
Foreign control	131	165	18 060	18 188	39 506	43 735	833	868	1 835	2 027	6 191	6 888	2 462	2 962	68 948	74 832
Total corporations	3 562	4 117	46 250	48 887	72 108	84 043	4 997	5 370	41 767	46 199	30 366	35 461	10 388	12 184	209 437	236 261
Sales																
Canadian control																
Private sector	x	x	18 163	21 190	106 928	121 953	x	x	43 426	50 572	172 583	200 179	36 963	41 674	420 356	480 603
Government	x	x	1 150	1 517	7 655	9 282	x	x	22 383	24 008	11 855	11 022	1 791	2 324	44 862	48 197
Foreign control	284	324	20 650	22 869	115 729	133 608	3 465	2 941	3 770	4 242	44 387	48 659	7 412	8 277	195 690	220 920
Total corporations	8 654	9 756	39 963	45 576	230 313	264 842	17 428	18 595	69 580	78 814	228 825	598 604	46 146	52 276	660 908	749 720
Profits																
Canadian control																
Private sector	x	x	1 304	3 216	3 335	5 218	x	x	4 107	4 669	3 714	5 097	1 815	2 280	15 455	21 940
Government	x	x	-13	-618	-270	499	x	x	1 578	1 475	1 862	1 987	445	634	3 604	3 977
Foreign control	15	47	6 482	6 981	5 730	9 867	131	150	430	510	871	1 142	859	1 076	14 515	19 772
Total corporations	368	511	7 773	9 579	8 795	15 584	957	1 143	6 115	6 654	6 447	8 228	3 120	3 990	33 575	45 689

Note: Figures may not add up to totals due to rounding.

P Preliminary; x Confidential.

TABLE 81. CANADA, CAPITAL AND REPAIR EXPENDITURES BY SELECTED INDUSTRIAL SECTOR, 1985-87

		Capital Expenditures			Repair Expenditures			Capital and Repair Expenditures		
		Construction	Machinery and Equipment	Total	Construction	Machinery and Equipment	Total	Construction	Machinery and Equipment	Total
						($ million)				
Agriculture	1985	849.0	2 288.5	3 137.5	324.6	1 275.7	1 600.3	1 173.6	3 564.2	4 737.8
	1986^{P}	761.6	2 130.4	2 892.0	342.7	1 337.1	1 679.8	1 104.3	3 467.5	4 571.8
	1987^{f}	736.7	1 992.9	2 729.6	350.3	1 428.1	1 778.4	1 087.0	3 421.0	4 508.0
Forestry	1985	109.4	95.7	205.1	78.6	245.2	323.8	188.0	340.9	528.9
	1986^{P}	97.1	113.9	211.0	72.4	197.6	270.0	169.5	311.5	481.0
	1987^{f}	115.6	127.5	243.1	87.0	214.5	301.5	202.6	342.0	544.6
Mining[1]	1985	9 273.0	1 632.2	10 905.2	518.1	2 137.2	2 655.3	9 791.1	3 769.4	13 560.5
	1986^{P}	6 089.0	1 078.3	7 167.3	432.1	2 073.6	2 505.7	6 521.1	3 151.9	9 673.0
	1987^{f}	5 740.1	1 081.0	6 821.1	420.1	2 078.4	2 498.5	6 160.2	3 159.4	9 319.6
Construction	1985	240.2	960.7	1 200.9	59.0	925.7	984.7	299.2	1 886.4	2 185.6
	1986^{P}	289.0	1 155.0	1 444.0	59.1	924.2	983.3	348.1	2 079.2	2 427.3
	1987^{f}	312.1	1 247.6	1 559.7	59.7	933.4	993.1	371.8	2 181.0	2 552.8
Housing	1985	21 169.8	-	21 169.8	2 975.1	-	2 975.1	24 144.9	-	24 144.9
	1986^{P}	25 593.4	-	25 593.4	3 042.9	-	3 042.9	28 636.3	-	28 636.3
	1987^{f}	28 487.8	-	28 487.8	3 112.4	-	3 112.4	31 600.2	-	31 600.2
Manufacturing	1985	2 565.6	8 950.5	11 516.1	894.1	5 187.8	6 081.9	3 459.7	14 138.3	17 598.0
	1986^{P}	2 417.4	11 492.1	13 909.5	864.0	5 168.2	6 032.2	3 281.4	16 660.3	19 941.7
	1987^{f}	2 604.4	13 331.9	15 936.3	957.0	5 408.0	6 365.0	3 561.4	18 739.9	22 301.3
Utilities	1985	6 770.1	6 905.3	13 675.4	1 971.3	5 041.7	7 013.0	8 741.4	11 947.0	20 688.4
	1986^{P}	6 726.6	6 929.8	13 656.4	1 940.3	5 123.7	7 064.0	8 666.9	12 053.5	20 720.4
	1987^{f}	7 622.5	7 889.2	15 511.7	2 013.2	5 289.9	7 303.1	9 635.7	13 179.1	22 814.8
Trade	1985	666.6	1 801.2	2 467.8	242.2	359.3	601.5	908.8	2 160.5	3 069.3
	1986^{P}	658.9	1 807.4	2 466.3	215.6	328.9	544.5	874.5	2 136.3	3 010.8
	1987^{f}	934.5	1 998.7	2 933.2	216.6	328.7	545.3	1 151.1	2 327.4	3 478.5
Other[2]	1985	16 445.9	9 780.3	26 226.2	2 829.2	1 367.8	4 197.0	19 275.1	11 148.1	30 423.2
	1986^{P}	17 891.2	10 476.5	28 367.7	2 911.8	1 533.2	4 445.0	20 803.0	12 009.7	32 812.7
	1987^{f}	20 133.1	11 698.1	31 831.2	3 070.3	1 675.2	4 745.5	23 203.4	13 373.3	36 576.7
Total	1985	58 089.6	32 414.4	90 504.0	9 892.2	16 540.4	26 432.6	67 981.8	48 954.8	116 936.6
	1986^{P}	60 524.2	35 183.4	95 707.6	9 880.9	16 686.5	26 567.4	70 405.1	51 869.9	122 275.0
	1987^{f}	66 686.8	39 366.9	106 053.7	10 286.6	17 356.2	27 642.8	76 973.4	56 723.1	133 696.5
Mining as a percentage of total	1985	16.0	5.0	12.0	5.2	12.9	10.0	14.4	7.7	11.6
	1986^{P}	10.1	3.1	7.5	4.4	12.4	9.4	9.3	6.1	7.9
	1987^{f}	8.6	2.7	6.4	4.1	12.0	9.0	8.0	5.6	7.0

[1] Includes mines, quarries and oil wells. [2] Includes finance, real estate, insurance, commercial services, institutions and government departments.
^{P} Preliminary; ^{f} Forecast; - Nil.

TABLE 82. CANADA, CAPITAL AND REPAIR EXPENDITURES IN MINING[1] BY GEOGRAPHICAL REGION, 1985-87

		Capital Expenditures			Repair Expenditures			Capital and Repair Expenditures		
		Construction	Machinery and Equipment	Total	Construction	Machinery and Equipment	Total	Construction	Machinery and Equipment	Total
						($ million)				
Atlantic Region	1985	1 389.3	176.8	1 566.1	14.4	176.3	190.7	1 403.7	353.1	1 756.8
	1986P	806.0	140.6	946.6	16.7	182.6	199.3	822.7	323.2	1 145.9
	1987f	560.9	101.5	662.4	17.0	180.8	197.8	577.9	282.3	860.2
Quebec	1985	280.4	67.8	348.2	31.2	197.3	228.5	311.6	265.1	526.7
	1986P	255.0	60.4	315.4	22.1	185.6	207.7	277.1	246.0	523.1
	1987f	213.0	83.3	296.3	21.3	187.1	208.4	234.3	270.4	504.7
Ontario	1985	494.6	143.8	638.4	47.2	343.6	390.8	541.8	487.4	1 029.2
	1986P	385.2	149.4	534.6	41.5	339.4	380.9	426.7	488.8	915.5
	1987f	475.6	198.6	674.2	42.4	343.6	386.0	518.0	542.2	1 060.2
Prairie Region	1985	5 603.2	1 104.3	6 707.5	364.5	957.0	1 321.5	5 967.7	2 061.3	8 029.0
	1986P	3 643.7	623.6	4 267.3	305.4	923.1	1 228.5	3 949.1	1 546.7	5 495.8
	1987f	3 722.5	574.0	4 296.5	294.6	925.2	1 219.8	4 017.1	1 499.2	5 516.3
British Columbia	1985	616.3	111.4	727.7	44.4	398.0	442.4	660.7	509.4	1 170.1
	1986P	377.8	92.1	469.9	39.6	384.6	424.2	417.4	476.7	894.1
	1987f	540.1	93.8	633.9	40.6	394.4	435.0	580.7	488.2	1 068.9
Yukon and Northwest Territories	1985	889.2	28.1	917.3	16.4	65.0	81.4	905.6	93.1	998.7
	1986P	621.3	12.2	633.5	6.8	58.3	65.1	628.1	70.5	678.6
	1987f	228.0	29.8	257.8	4.2	47.3	51.5	232.2	77.1	309.3
Canada, total	1985	9 273.0	1 632.2	10 905.2	518.1	2 137.2	2 655.3	9 791.1	3 769.4	13 560.5
	1986P	6 089.0	1 078.3	7 167.3	432.1	2 073.6	2 505.7	6 521.1	3 151.9	9 673.0
	1987f	5 740.1	1 081.0	6 821.1	420.1	2 078.4	2 498.5	6 160.2	3 159.4	9 319.6

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[1] Includes mines, quarries and oil wells.
P Preliminary; f Forecast.

TABLE 83. CANADA, CAPITAL AND REPAIR EXPENDITURES IN MINING[1] AND MINERAL MANUFACTURING INDUSTRIES, 1985-87

	1985			1986[p]			1987[f]		
	Capital	Repair	Total	Capital	Repair	Total	Capital	Repair	Total
					($ million)				
Mining industry									
Metal mines									
Gold	504.7	113.5	608.2	453.4	116.2	569.6	656.5	133.1	789.6
Silver-lead-zinc	95.3	94.9	190.2	56.8	88.6	145.4	98.8	89.8	188.6
Copper-gold-silver	264.5	246.3	510.8	216.1	229.1	445.2	219.9	234.2	454.1
Iron	113.0	201.4	314.4	115.3	196.9	312.2	84.5	184.9	269.4
Other metal mines	398.4	304.8	703.2	319.6	282.9	602.5	326.2	277.0	603.2
Total metal mines	1 375.9	950.9	2 326.8	1 161.2	913.7	2 074.9	1 385.9	919.0	2 304.9
Nonmetal mines									
Asbestos	34.4	50.5	84.9	35.1	40.4	75.5	43.8	37.1	80.9
Other nonmetal mines[2]	889.3	518.3	1 407.6	582.9	510.3	1 093.2	596.0	528.8	1 124.8
Total nonmetal mines	923.7	568.8	1 492.5	618.0	550.7	1 168.7	639.8	565.9	1 205.7
Mineral fuels									
Oil, crude and gas[3]	8 605.6	1 135.6	9 741.2	5 388.1	1 041.3	6 429.4	4 795.4	1 013.6	5 809.0
Total mining industries	10 905.2	2 655.3	13 560.5	7 167.3	2 505.7	9 673.0	6 821.1	2 498.5	9 319.6
Mineral manufacturing									
Primary metal industries									
Iron and steel mills	439.4	766.0	1 205.4	786.3	786.7	1 573.0	956.6[e]	811.2	1 767.8
Steel pipe and tube mills	114.3	74.6	188.9	154.3	60.0	214.3	74.6[e]	61.0	135.6
Iron foundries	36.7	62.5	99.2	47.5	56.6	104.1	33.5[e]	57.3	90.8
Smelting and refining	946.4	374.5	1 320.9	577.8	385.9	963.7	510.5[e]	449.9	960.4
Aluminum rolling, casting and extruding	40.1	52.5	92.6	45.9	56.0	101.9	63.9[e]	53.1	117.0
Copper and copper alloy, rolling, casting and extruding	6.4	8.5	14.9	8.5	8.7	17.2	19.7[e]	8.9	28.6
Metal rolling, casting and extruding	29.5	17.7	47.2	29.8	18.5	48.3	26.6[e]	14.5	41.1
Total primary metal industries	1 612.8	1 356.3	2 969.1	1 650.1	1 372.4	3 022.5	1 685.5	1 455.9	3 141.4
Nonmetallic mineral products									
Cement	27.7	72.0	99.7	42.3	69.6	111.9	53.8[e]	75.9	129.7
Stone products	1.2	0.5	1.7	1.6	1.6	3.2	1.3[e]	1.6	2.9
Concrete products	32.3	30.8	63.1	41.0	25.1	66.1	39.4[e]	21.7	61.1
Ready-mix concrete	32.1	57.4	89.5	31.8	61.3	93.1	52.6[e]	55.5	108.1
Clay products	4.8	4.6	9.4	23.8	6.9	30.7	23.7[e]	7.3	31.0
Glass and glass products	84.2	41.7	125.9	93.9	33.2	127.1	85.2[e]	28.8	114.0
Abrasives	10.2	16.3	26.5	12.5	14.5	27.0	13.4[e]	11.8	25.2
Lime	5.8	9.5	15.3	6.7	4.7	11.4	7.5[e]	5.3	12.8
Other nonmetallic mineral products	34.1	59.0	93.1	48.0	61.7	109.7	63.0[e]	61.0	124.0
Total nonmetallic mineral products	232.4	291.8	524.2	301.6	278.6	580.2	339.9	268.9	608.8
Petroleum and coal products	331.6	284.1	615.7	408.2	285.4	693.6	545.0[e]	353.2	898.2
Petroleum refineries									
Petroleum and coal products	4.1	3.8	7.9	4.4	13.3	17.7	5.1[e]	12.8	17.9
Total petroleum and coal products	335.7	287.9	623.6	412.6	298.7	711.3	550.1	366.0	916.1
Total mineral manufacturing industries	2 180.9	1 936.0	4 116.9	2 364.3	1 949.7	4 314.0	2 575.5	2 090.9	4 666.4
Total mining and mineral manufacturing industries	13 086.1	4 591.3	17 677.4	9 531.6	4 455.4	13 987.0	9 396.6	4 589.4	13 986.0

[1] Does not include cement, lime and clay products (domestic clay) manufacturing, smelting and refining. [2] Includes coal mines, gypsum, salt, potash and miscellaneous nonmetal mines and quarrying. [3] The total of capital expenditures shown under "petroleum and gas" is equal to the total capital expenditure under the column entitled "petroleum and natural gas extraction" and under the column "natural gas processing plants" of Table 86.
[p] Preliminary; [f] Forecast; [e] Estimate.

TABLE 84. CANADA, CAPITAL AND REPAIR EXPENDITURES IN THE MINING INDUSTRY[1], 1981-87

	1981	1982	1983	1984	1985	1986P	1987f
				($ million)			
Metal mines							
Capital							
Construction	1 331.3	1 099.4	839.1	942.2	1 053.5	858.4	1 006.7
Machinery	576.4	370.6	312.0	372.7	322.4	302.8	379.2
Total	1 907.7	1 470.0	1 151.1	1 314.9	1 375.9	1 161.2	1 385.9
Repair							
Construction	151.9	112.4	93.3	99.6	104.5	83.1	84.3
Machinery	900.8	805.1	728.0	861.1	846.4	830.6	834.7
Total	1 052.7	917.5	821.3	960.7	950.9	913.7	919.0
Total capital and repair	2 960.4	2 387.5	1 972.4	2 275.6	2 326.8	2 074.9	2 304.9
Nonmetal mines[2]							
Capital							
Construction	647.8	888.6	1 123.3	658.6	573.6	324.9	406.9
Machinery	417.7	563.3	433.9	571.7	350.1	293.1	232.9
Total	1 065.5	1 451.9	1 557.2	1 230.3	923.7	618.0	639.8
Repair							
Construction	26.0	28.6	25.5	47.2	39.3	26.8	26.0
Machinery	447.8	431.8	401.5	454.8	529.5	523.9	539.9
Total	473.8	460.4	427.0	502.0	568.8	550.7	565.9
Total capital and repair	1 539.3	1 912.3	1 984.2	1 732.3	1 492.5	1 168.7	1 205.7
Mineral fuels							
Capital							
Construction	5 825.1	6 019.2	6 034.1	6 643.5	7 645.9	4 905.7	4 326.5
Machinery	1 206.3	1 420.5	880.6	686.7	959.7	482.4	468.9
Total	7 031.4	7 439.7	6 914.7	7 330.2	8 605.6	5 388.1	4 795.4
Repair							
Construction	514.4	484.4	427.4	283.4	374.3	322.2	309.8
Machinery	639.0	698.3	656.7	709.5	761.3	719.1	703.8
Total	1 153.4	1 182.7	1 084.1	992.9	1 135.6	1 041.3	1 013.6
Total capital and repair	8 184.8	8 622.4	7 998.8	8 323.1	9 741.2	6 429.4	5 809.0
Total mining							
Capital							
Construction	7 804.2	8 007.2	7 996.5	8 244.3	9 273.0	6 089.0	5 740.1
Machinery	2 200.4	2 354.4	1 626.5	1 631.1	1 632.2	1 078.3	1 081.0
Total	10 004.6	10 361.6	9 623.0	9 875.4	10 905.2	7 167.3	6 821.1
Repair							
Construction	692.5	625.4	546.2	430.2	518.1	432.1	420.1
Machinery	1 987.6	1 935.2	1 786.2	2 025.4	2 137.2	2 073.6	2 078.4
Total	2 680.1	2 560.6	2 332.4	2 455.6	2 655.3	2 505.7	2 498.5
Total capital and repair	12 684.7	12 922.2	11 955.4	12 331.0	13 560.5	9 673.0	9 319.6

[1] Does not include cement, lime and clay products (domestic clays) manufacturing, smelting and refining. [2] Includes coal mines, asbestos, gypsum, salt, potash, miscellaneous nonmetals, quarrying and sand pits.
P Preliminary; f Forecast.

TABLE 85. CANADA, CAPITAL AND REPAIR EXPENDITURES IN THE MINERAL MANUFACTURING INDUSTRIES, 1981-87

	1981	1982	1983	1984	1985	1986P	1987f
				($ million)			
Primary metal industries[1]							
Capital							
Construction	330.1	278.3	112.5	318.6	593.8	334.3	299.9
Machinery	1 289.6	927.5	550.6	712.6	1 019.0	1 315.8	1 385.6
Total	1 619.7	1 205.8	663.1	1 031.2	1 612.8	1 650.1	1 685.5
Repair							
Construction	139.0	99.2	111.4	119.6	125.2	121.3	143.9
Machinery	1 053.3	1 021.6	1 053.1	1 215.7	1 231.1	1 251.1	1 312.0
Total	1 192.3	1 120.8	1 164.5	1 335.3	1 356.3	1 372.4	1 455.9
Total capital and repair	2 812.0	2 326.6	1 827.6	2 366.5	2 969.1	3 022.5	3 141.4
Nonmetallic mineral products[2]							
Capital							
Construction	93.4	32.0	14.8	26.6	39.2	31.9	41.0
Machinery	254.0	134.4	125.5	151.0	193.2	269.7	298.9
Total	347.4	166.4	140.3	177.6	232.4	301.6	339.9
Repair							
Construction	23.7	20.7	20.7	26.3	21.2	24.0	23.0
Machinery	227.5	211.1	204.1	236.5	270.6	254.6	245.9
Total	251.2	231.8	224.8	262.8	291.8	278.6	268.9
Total capital and repair	598.6	398.2	365.1	440.4	524.2	580.2	608.8
Petroleum and coal products							
Capital							
Construction	629.9	890.8	629.6	321.4	248.3	309.5	406.7
Machinery	215.0	333.7	211.2	111.0	87.4	103.1	143.4
Total	844.9	1 224.5	840.8	432.4	335.7	412.6	550.1
Repair							
Construction	212.9	218.5	196.0	230.3	213.0	222.5	274.4
Machinery	89.1	101.2	68.6	79.3	74.9	76.2	91.6
Total	302.0	319.7	264.6	309.6	287.9	298.7	366.0
Total capital and repair	1 146.9	1 544.2	1 105.4	742.0	623.6	711.3	916.1
Total mineral manufacturing industries							
Capital							
Construction	1 053.4	1 201.1	756.9	666.6	881.3	675.7	747.6
Machinery	1 758.6	1 395.6	887.3	974.6	1 299.6	1 688.6	1 827.9
Total	2 812.0	2 596.7	1 644.2	1 641.2	2 180.9	2 364.3	2 575.5
Repair							
Construction	375.6	338.4	328.1	376.2	359.4	367.8	441.4
Machinery	1 369.9	1 333.9	1 328.1	1 531.5	1 576.6	1 581.9	1 649.5
Total	1 745.5	1 672.3	1 653.9	1 907.7	1 936.0	1 949.7	2 090.9
Total capital and repair	4 557.5	4 269.0	3 298.1	3 548.9	4 116.9	4 314.0	4 666.4

[1] Includes smelting and refining. [2] Includes cement, lime and clay products manufacturing.
P Preliminary; f Forecast.

TABLE 86. CANADA, CAPITAL EXPENDITURES IN THE PETROLEUM, NATURAL GAS AND ALLIED INDUSTRIES[1], 1981-87

	Petroleum and Natural Gas Extraction	Transportation Including Rail, Water and Pipelines	Marketing (Chiefly Outlets of Oil Companies)	Natural Gas Distribution	Petroleum and Coal Products Industries	Natural Gas Processing Plants	Oil and Gas Drilling Contractors	Total Capital Expenditures
				($ million)				
1981	6 444.9	1 745.7	264.1	408.7	844.9	311.6	274.9	10 294.8
1982	6 743.4	1 994.3	320.5	517.6	1 224.5	522.8	173.5	11 496.6
1983	6 563.5	660.5	374.5	516.8	840.8	195.8	155.4	9 307.3
1984	6 946.4	795.4	422.9	604.1	432.4	340.0	43.8	9 585.0
1985	8 187.6	664.2	356.8	603.5	335.7	337.7	80.1	10 565.6
1986P	5 196.6	618.7	329.5	469.8	412.6	164.2	27.2	7 218.6
1987f	4 217.3	448.4	412.4	480.0	565.2	157.1	13.3	6 293.7

[1] The petroleum and natural gas industries in this table include all companies engaged in whole or in part in oil and gas activities.
P Preliminary; f Forecast.

TABLE 87. CANADA, TOTAL INTRAMURAL RESEARCH AND DEVELOPMENT EXPENDITURES FOR MINING-RELATED INDUSTRIES IN CURRENT AND CONSTANT (1978) DOLLARS, 1981-87

	1981	1982	1983	1984	1985	1986P	1987f
				($ million)			
Current dollars							
Mining industry	131	132	92	115	127	110	116
Mines	51	48	43	47	52	56	60
Oil and gas wells	80	85	49	68	75	54	56
Mineral manufacturing	391	362	297	358	345	335	334
Ferrous primary metals	24	23	21	26	27	28	30
Nonferrous primary metals	86	86	82	95	94	102	107
Nonmetallic mineral products	9	9	10	19	19	16	16
Petroleum products	272	244	184	218	205	189	181
Constant dollars							
Mining industry	97	90	60	72	71	62	64
Mines	38	32	28	30	31	31	33
Oil and gas wells	59	58	32	42	45	30	31
Mineral manufacturing	291	247	194	224	209	188	183
Ferrous primary metals	18	16	14	16	16	16	16
Nonferrous primary metals	64	59	54	59	57	57	59
Nonmetallic mineral products	7	6	7	12	12	9	9
Petroleum products	202	166	119	137	124	106	99

P Preliminary; f Forecast.

TABLE 88. CANADA, CURRENT AND CAPITAL INTRAMURAL RESEARCH AND DEVELOPMENT EXPENDITURES FOR MINING-RELATED INDUSTRIES, 1981-87

	1981	1982	1983	1984	1985	1986^{P}	1987^{f}
				($ million)			
Capital expenditures							
Mining industry	38	36	21	21	28	10	17
Mines	3	4	6	6	4	3	5
Oil and gas wells	34	33	15	15	24	7	11
Mineral manufacturing	59	81	48	97	82	56	48
Ferrous primary metals	2	1	1	1	3	3	3
Nonferrous primary metals	17	10	5	9	5	7	6
Nonmetallic mineral products	1	1	1	6	6	2	2
Petroleum products	39	69	41	81	68	44	37
Current expenditures							
Mining industry	93	96	71	94	99	100	99
Mines	48	44	38	42	48	52	55
Oil and gas wells	46	52	33	52	51	48	44
Mineral manufacturing	333	281	250	261	262	279	284
Ferrous primary metals	22	22	21	25	23	25	26
Nonferrous primary metals	70	76	77	86	89	95	101
Nonmetallic mineral products	8	8	9	13	14	14	14
Petroleum products	233	175	143	137	136	145	143
Total expenditures							
Mining industry	131	132	92	115	127	110	116
Mines	51	48	43	47	52	56	60
Oil and gas wells	80	85	49	68	75	54	56
Mineral manufacturing	391	362	297	358	345	335	334
Ferrous primary metals	24	23	21	26	27	28	30
Nonferrous primary metals	86	86	82	95	94	102	107
Nonmetallic mineral products	9	9	10	19	19	16	16
Petroleum products	272	244	184	218	205	189	181

P Preliminary; ^{f} Forecast.

Tariffs, 1988

TARIFFS

Canadian and U.S. Tariffs for Minerals and Metals Annotated in the Harmonized System Nomenclature, 1988, Showing the Phase-Out Period for Tariffs Under the Free Trade Agreement (FTA)

Explanatory Notes: MFN = Most Favoured Nation rate under the General Agreement on Trade and Tariffs, which is the basis for eliminating tariffs under the Canada-U.S. Free Trade Agreement. Tariffs will be eliminated according to three formulas: A for January 1, 1989; B for those to be phased-out in five equal steps beginning January 1, 1989; C for those to be phased-out in ten equal steps beginning January 1, 1989. D signifies that tariffs are already zero. GPT = General Preferential Tariff granted to most developing countries. Canada implemented the HS tariff nomenclature on January 1, 1988, but the United States is not expected to make the changeover until January 1, 1989.

Sources: Canada, Notice of Ways and Means Motion, Customs Tariff; tabled in the House of Commons, Ottawa, October 2, 1987. United States, Proposed United States Tariff Schedule Annotated in the Harmonized System Nomenclature; Office of the USTR, Washington, July 1987. The Canada-U.S. Free Trade Agreement; Department of External Affairs, Ottawa, December 10, 1987.

(1) Refer to United States Tariff Schedule for details.
.. Not applicable.

TARIFF SCHEDULES

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69	Ceramic Products	73.34
71	Precious or Semi-Precious Stones, Precious Metals	73.37
72	Iron and Steel	73.40
74	Copper	73.43
75	Nickel	73.45
76	Aluminum	73.46
78	Lead	73.47
79	Zinc	73.48
80	Tin	73.49
81	Other Base Metals	73.50

CHAPTER 25. SALT; SULPHUR; EARTHS AND STONE; PLASTERING MATERIALS, LIME AND CEMENT

Tariff Item	Description of Goods	Canada		United States		Phase-Out in FTA
		MFN	GPT	MFN	GPT	
2501.00	Salt (including table salt and denatured salt) and pure sodium chloride, whether or not in aqueous solution; sea water					
2501.00.10	---Table salt made by an admixture of other ingredients when containing 90% or more of pure sodium chloride	4%	2.5%	Free	Free	A
2501.00.90	---Other	Free	Free	Free	Free	D
2502.00.00	Unroasted iron pyrites	Free	Free	Free	Free	D
25.03	Sulphur of all kinds, other than sublimed sulphur, precipitated sulphur and colloidal sulphur					
2503.10.00	-Crude or unrefined sulphur	Free	Free	Free	Free	D
2503.90.00	-Other	Free	Free	Free	Free	D
25.04	Natural graphite					
2504.10	-In powder or in flakes					
2504.10.10	---In powder	9.2%	6%	0.7¢/kg	Free	A
2504.10.20	---In flakes	4%	2.5%	(1)	(1)	A
2504.90.00	-Other	Free	Free	Free	Free	D
25.05	Natural sands of all kinds, whether or not coloured, other than metal-bearing sands of Chapter 26					
2505.10.00	-Silica sand and quartz sands	Free	Free	Free	Free	D
2505.90.00	-Other	Free	Free	Free	Free	D
25.06	Quartz (other than natural sands); quartzite, whether or not roughly trimmed or merely cut, by sawing or otherwise, into blocks or slabs of a rectangular (including square) shape					
25.06.10.00	-Quartz	Free	Free	Free	Free	D

	-Quartzite:					
2506.21.00	--Crude or roughly trimmed	Free	Free	Free	Free	D
2506.29.00	--Other	Free	Free	Free	Free	D
2507.00.00	Kaolin and other kaolinic clays, whether or not calcined	Free	Free	32.5¢/t	Free	A
25.08	Other clays (not including expanded clays of heading No. 68.06), andalusite, kyanite and sillimanite, whether or not calcined; mullite; chamotte or dinas earths					
2508.10.00	-Bentonite	Free	Free	39.4¢/t	Free	A
2508.20.00	-Decolourizing earths and fuller's earth	Free	Free	24.6¢/t	Free	A
2508.30.00	-Fire-clay	Free	Free	49.2¢/t	Free	A
2508.40.00	-Other clays	Free	Free	46.7¢/t	Free	A
2508.50.00	-Andalusite, kyanite and sillimanite	Free	Free	Free	Free	D
2508.60.00	-Mullite	Free	Free	4.9%	Free	A
2508.70.00	-Chamotte or dinas earths	Free	Free	Free	Free	D
2509.00	Chalk					
2509.00.10	---Whiting	6.8%	Free	Free	Free	A
2509.00.90	---Other	Free	Free	1.4%	Free	A
25.10	Natural calcium phosphates, natural aluminum calcium phosphates and phosphatic chalk					
2510.10.00	-Unground	Free	Free	Free	Free	D
2510.20.00	-Ground	Free	Free	Free	Free	D
25.11	Natural barium sulphate (barytes); natural barium carbonate (witherite), whether or not calcined					
2511.10.00	-Natural barium sulphate (barytes)	10%	Free	(1)	(1)	A
2511.20.00	-Natural barium carbonate (witherite)	9.2%	Free	3%	Free	A

CHAPTER 25 (cont'd)

Tariff Item	Description of Goods	Canada		United States		Phase-Out in FTA
		MFN	GPT	MFN	GPT	
2512.00.00	Siliceous fossil meals (for example, kieselguhr, tripolite and diatomite) and similar siliceous earths, whether or not calcined, of an apparent specific gravity of 1 or less	Free	Free	Free	Free	D
25.13	Pumice stone; emery; natural corundum, natural garnet and other natural abrasives, whether or not heat-treated					
	-Pumice stone:					
2513.11.00	--Crude or in irregular pieces, including crushed pumice ("bimskies")	Free	Free	Free	Free	D
2513.19.00	--Other	Free	Free	0.3¢/kg	Free	A
	-Emery, natural corundum, natural garnet and other natural abrasives:					
2513.21.00	--Crude or in irregular pieces	Free	Free	Free	Free	D
2513.29.00	--Other	Free	Free	0.7¢/kg	Free	A
2514.00	Slate, whether or not roughly trimmed or merely cut, by sawing or otherwise, into blocks or slabs of a rectangular (including square) shape					
2514.00.10	---Crude or roughly trimmed	Free	Free	3.7%	Free	A
2514.00.20	---Merely cut, by sawing or otherwise, into blocks or slabs of a rectangular (including square) shape	5.5%	3.5%	3.7%	Free	A
2514.00.90	---Other, including powder and waste	10.2%	6.5%	3.7%	Free	A
25.15	Marble, travertine, ecaussine and other calcareous monumental or building stone of an apparent specific gravity of 2.5 or more, and alabaster, whether or not roughly trimmed or merely cut, by sawing or otherwise, into blocks or slabs of a rectangular (including square) shape					

	-Marble and travertine:					
2515.11.00	--Crude or roughly trimmed	Free	Free	$3.46/M^3	Free	A
2515.12.00	--Merely cut, by sawing or otherwise, into blocks or slabs of a rectangular (including square) shape	4%	Free	(1)	(1)	A
2515.20	-Ecaussine and other calcareous monumental or building stone; alabaster					
2515.20.10	---Crude or roughly trimmed	Free	Free	6%	Free	A
2515.20.20	---Merely cut, by sawing or otherwise, into blocks or slabs of a rectangular (including square) shape	5.5%	3.5%	6%	Free	A
25.16	Granite, porphyry, basalt, sandstone and other monumental or building stone, whether or not roughly trimmed or merely cut, by sawing or otherwise, into blocks or slabs of a rectangular (including square) shape					
	-Granite:					
2516.11.00	--Crude or roughly trimmed	Free	Free	Free	Free	D
2516.12.00	--Merely cut, by sawing or otherwise, into blocks or slabs of a rectangular (including square) shape	5.5%	Free	4.2%	Free	A
	-Sandstone:					
2516.21.00	--Crude or roughly trimmed	Free	Free	Free	Free	D
2516.22.00	--Merely cut, by sawing or otherwise, into blocks or slabs of a rectangular (including square) shape	5.5%	3.5%	6%	Free	A
2516.90	-Other monumental or building stone					
2516.90.10	---Crude or roughly trimmed	Free	Free	6%	Free	A
2516.90.20	---Merely cut, by sawing or otherwise, into blocks or slabs of a rectangular (including square) shape	5.5%	3.5%	6%	Free	A

CHAPTER 25 (cont'd)

Tariff Item	Description of Goods	Canada		United States		Phase-Out in FTA
		MFN	GPT	MFN	GPT	
25.17	Pebbles, gravel, broken or crushed stone, of a kind commonly used for concrete aggregates, for road metalling or for railway or other ballast, shingle and flint, whether or not heat-treated; macadam of slag, dross or similar industrial waste, whether or not incorporating the materials cited in the first part of the heading; tarred macadam; granules, chippings and powder, of stones of heading No. 25.15 or 25.16, whether or not heat-treated					
2517.10.00	-Pebbles, gravel, broken or crushed stone, of a kind commonly used for concrete aggregates, for road metalling or for railway or other ballast, shingle and flint, whether or not heat-treated	Free	Free	Free	Free	D
2517.20.00	-Macadam of slag, dross or similar industrial waste, whether or not incorporating the materials cited in subheading No. 2517.10	Free	Free	4.9%	Free	A
2517.30.00	-Tarred macadam	10.2%	6.5%	4.9%	Free	A
	-Granules, chippings and powder, of stones of heading No. 25.15 or 25.16, whether or not heat-treated:					
2517.41.00	--Of marble	Free	Free	Free	Free	D
2517.49	--Other					
2517.49.10	---Limestone; roofing granules	Free	Free	Free	Free	D
2517.49.90	---Other	10.2%	6.5%	Free	Free	B
25.18	Dolomite, whether or not calcined; dolomite roughly trimmed or merely cut, by sawing or otherwise, into blocks or slabs of a rectangular (including square) shape; agglomerated dolomite (including tarred dolomite)					
2518.10.00	-Dolomite not calcined	4%	Free	Free	Free	A
2518.20.00	-Calcined dolomite	9.2%	6%	6%	Free	A

2518.30.00	-Agglomerated dolomite (including tarred dolomite)	10.2%	6.5%	4.9%	Free	A
25.19	Natural magnesium carbonate (magnesite); fused magnesia; dead-burned (sintered) magnesia, whether or not containing small quantities of other oxides added before sintering; other magnesium oxide, whether or not pure					
2519.10	-Natural magnesium carbonate (magnesite)					
2519.10.10	---Crude rock form	Free	Free	Free	Free	D
2519.10.90	---Other	9.2%	6%	Free	Free	B
2519.90	-Other					
2519.90.10	---Magnesium oxide not less than 94% pure	Free	Free	0.04¢/kg	Free	A
2519.90.90	---Other	9.2%	6%	(1)	(1)	A
25.20	Gypsum; anhydrite; plasters (consisting of calcined gypsum or calcium sulphate) whether or not coloured, with or without small quantities of accelerators or retarders					
2520.10.00	-Gypsum; anhydrite	Free	Free	Free	Free	D
2520.20	-Plasters					
2520.20.10	---Dental plasters	Free	Free	41.3¢/t	Free	A
2520.20.90	---Other	88.2¢/t	Free	41.3¢/t	Free	A
2521.00.00	Limestone flux; limestone and other calcareous stone, of a kind used for the manufacture of lime or cement	Free	Free	Free	Free	D
25.22	Quicklime, slaked lime and hydraulic lime					
2522.10.00	-Quicklime	Free	Free	Free	Free	D
2522.20.00	-Slaked lime	Free	Free	Free	Free	D
2522.30.00	-Hydraulic lime	Free	Free	Free	Free	D
25.23	Portland cement, aluminous cement, slag cement, supersulphate cement and similar hydraulic cements, whether or not coloured or in the form of clinkers					
2523.10.00	-Cement clinkers	Free	Free	Free	Free	D

CHAPTER 25 (cont'd)

Tariff Item	Description of Goods	Canada		United States		Phase-Out in FTA
		MFN	GPT	MFN	GPT	
	-Portland cement:					
2523.21.00	--White cement, whether or not artificially coloured	81.59¢/t	54.25¢/t	22.5¢/t	Free	A
2523.29.00	--Other	Free	Free	Free	Free	D
2523.30.00	-Aluminous cement	Free	Free	Free	Free	D
2523.90.00	-Other hydraulic cements	Free	Free	Free	Free	D
2524.00	Asbestos					
2524.00.10	---Crude	Free	Free	Free	Free	D
2524.00.90	---Other	8%	5%	Free	Free	A
25.25	Mica, including splittings; mica waste					
2525.10.00	-Crude mica and mica rifted into sheets or splittings	Free	Free	Free	Free	D
2525.20	-Mica powder					
2525.20.10	---Of a particle size not exceeding 20 microns	4%	Free	2.4%	Free	B
2525.20.20	---Of a particle size exceeding 20 microns	10.2%	6.5%	2.4%	Free	B
2525.30.00	-Mica waste	Free	Free	Free	Free	D
25.26	Natural steatite, whether or not roughly trimmed or merely cut, by sawing or otherwise, into blocks or slabs of a rectangular (including square) shape; talc					
2526.10.00	-Not crushed, not powdered	9.2%	6%	0.04¢/kg	Free	B
2526.20	-Crushed or powdered					
2526.20.10	---Talc of a particle size not exceeding 20 microns	4%	Free	2.4%	Free	B
2526.20.90	---Other	9.2%	6%	2.4%	Free	B
2527.00	Natural cryolite; natural chiolite					
2527.00.10	---Natural cryolite	Free	Free	Free	Free	D
2527.00.20	---Natural chiolite	10.2%	6.5%	Free	Free	A

25.28	Natural borates and concentrates thereof (whether or not calcined), but not including borates separated from natural brine; natural boric acid containing not more than 85% of H_3BO_3, calculated on the dry weight					
2528.10.00	-Natural sodium borates	Free	Free	Free	Free	D
2528.90.00	-Other	Free	Free	Free	Free	D
25.29	Feldspar; leucite; nepheline and nepheline syenite; fluorspar					
2529.10.00	-Feldspar	Free	Free	Free	Free	D
	-Fluorspar:					
2529.21.00	--Containing by weight 97% or less of calcium fluoride	Free	Free	13.5%	Free	B
2529.22.00	--Containing by weight more than 97% of calcium fluoride	Free	Free	$2.07/t	Free	A
2529.30.00	-Leucite; nepheline and nepheline syenite	10.2%	6.5%	Free	Free	A
25.30	Mineral substances not elsewhere specified or included					
2530.10	-Vermiculite, perlite and chlorites, unexpanded					
2530.10.10	---Vermiculite or perlite	Free	Free	Free	Free	D
2530.10.20	---Chlorites	10.2%	6.5%	Free	Free	A
2530.20.00	-Kieserite, epsomite (natural magnesium sulphates)	10.2%	6.5%	(1)	(1)	A
2530.30.00	-Earth colours	7.5%	Free	Free	Free	A
2530.40.00	-Natural micaceous iron oxides	7.5%	Free	5.8%	Free	A
2530.90	-Other					
2530.90.10	---Meerschaum, amber, jet	Free	Free	Free	Free	D
2530.90.20	---Minerals of sodium carbonate such as trona, thermonatrite and nahcolite; minerals of sodium sulphate such as thenardite and mirabilite	12.5%	8%	Free	Free	C

Tariff Item	Description of Goods	Canada		United States		Phase-Out in FTA
		MFN	GPT	MFN	GPT	
2530.90.30	---Natural arsenic sulphides; lydite; earths; limestone (lithographic stone); broken pottery; ores of rare earth metals; wollastonite (natural calcium silicate); natural zirconium silicate	Free	Free	Free	Free	D
2530.90.40	---Pyrophyllite	Free	Free	Free	Free	D
2530.90.50	---Natural manganese oxides	Free	Free	Free	Free	D
2530.90.90	---Other	10.2%	4.5%	Free	Free	A

CHAPTER 26. ORES, SLAG AND ASH

Tariff Item	Description of Goods	Canada		United States		Phase-Out in FTA
		MFN	GPT	MFN	GPT	
26.01	Iron ores and concentrates, including roasted iron pyrites					
	-Iron ores and concentrates, other than roasted iron pyrites:					
2601.11.00	--Not agglomerated	Free	Free	Free	Free	D
2601.12.00	--Agglomerated	Free	Free	Free	Free	D
2601.20.00	-Roasted iron pyrites	Free	Free	Free	Free	D
2602.00.00	Manganese ores and concentrates, including manganiferous iron ores and concentrates with a manganese content of 20% or more, calculated on the dry weight	Free	Free	Free	Free	D
2603.00.00	Copper ores and concentrates	Free	Free	1.7¢/kg Pb	Free	A
2604.00.00	Nickel ores and concentrates	Free	Free	Free	Free	D
2605.00.00	Cobalt ores and concentrates	Free	Free	Free	Free	D
2606.00.00	Aluminum ores and concentrates	Free	Free	Free	Free	D
2607.00.00	Lead ores and concentrates	Free	Free	1.7¢/kg Pb	Free	C
2608.00.00	Zinc ores and concentrates	Free	Free	1.7¢/kg Pb	Free	C
2609.00.00	Tin ores and concentrates	Free	Free	Free	Free	D
2610.00.00	Chromium ores and concentrates	Free	Free	Free	Free	D
2611.00.00	Tungsten ores and concentrates	Free	Free	37.5¢/kg W	Free	A
26.12	Uranium or thorium ores and concentrates					
2612.10.00	-Uranium and concentrates	Free	Free	Free	Free	D
2612.20.00	-Thorium ores and concentrates	Free	Free	Free	Free	D

CHAPTER 26 (cont'd)

Tariff Item	Description of Goods	Canada		United States		Phase-Out in FTA
		MFN	GPT	MFN	GPT	
26.13	Molybdenum ores and concentrates					
2613.10.00	-Roasted	Free	Free	19.8¢/kg Mo	Free	C
2613.90.00	-Other	Free	Free	19.8¢/kg Mo	Free	B
2614.00.00	Titanium ores and concentrates	Free	Free	(1)	(1)	B,D
26.15	Niobium, tantalum, vanadium or zirconium ores and concentrates					
2615.10.00	-Zirconium ores and concentrates	Free	Free	Free	Free	D
2615.90.00	-Other	Free	Free	Free	Free	D
26.16	Precious metal ores and concentrates					
2616.10.00	-Silver ores and concentrates	Free	Free	1.7¢/kg Pb	Free	A
2616.90.00	-Other	Free	Free	1.7¢/kg Pb	Free	B
26.17	Other ores and concentrates					
2617.10.00	-Antimony ores and concentrates	Free	Free	Free	Free	D
2617.90.00	-Other	Free	Free	Free	Free	D
2618.00.00	Granulated slag (slag sand) from the manufacture of iron or steel	Free	Free	Free	Free	D
2619.00.00	Slag, dross (other than granulated slag), scalings and other waste from the manufacture of iron or steel	Free	Free	(1)	(1)	A,D
26.20	Ash and residues (other than from the manufacture of iron or steel), containing metals or metallic compounds					
	-Containing mainly zinc:					
2620.11.00	--Hard zinc spelter	Free	Free	1.5%	Free	C

2620.19.00	--Other	Free	Free	(1)	(1)	A,D
2620.20.00	-Containing mainly lead	Free	Free	0.7¢/kg Cu +0.7¢/kg Pb	Free	B
2620.30.00	-Containing mainly copper	Free	Free	0.7¢/kg Cu +0.7¢/kg Pb	Free	A
2620.40.00	-Containing mainly aluminum	Free	Free	Free	Free	D
2620.50.00	-Containing mainly vanadium	Free	Free	Free	Free	D
2620.90.00	-Other	Free	Free	(1)	(1)	A,B,D
2621.00.00	Other slag and ash, including seaweed ash (kelp)	Free	Free	Free	Free	D

CHAPTER 27. MINERAL FUELS, MINERAL OILS AND PRODUCTS OF THEIR DISTILLATION; BITUMINOUS SUBSTANCES; MINERAL WAXES

Tariff Item	Description of Goods	Canada MFN	Canada GPT	United States MFN	United States GPT	Phase-Out in FTA
27.01	Coal; briquettes, ovoids and similar solid fuels manufactured from coal					
	-Coal, whether or not pulverized, but not agglomerated:					
2701.11.00	--Anthracite	Free	Free	Free	Free	D
2701.12.00	--Bituminous coal	Free	Free	Free	Free	D
2701.19.00	--Other coal	Free	Free	Free	Free	D
2701.20.00	-Briquettes, ovoids and similar solid fuels manufactured from coal	Free	Free	Free	Free	D
27.02	Lignite, whether or not agglomerated, excluding jet					
2702.10.00	-Lignite, whether or not pulverized, but not agglomerated	Free	Free	Free	Free	D
2702.20.00	-Agglomerated lignite	Free	Free	Free	Free	D
2703.00.00	Peat (including peat litter), whether or not agglomerated	10.2%	6.5%	Free	Free	B
2704.00.00	Coke and semi-coke of coal, of lignite or of peat, whether or not agglomerated, retort carbon	Free	Free	Free	Free	D
2705.00.00	Coal gas, water gas, producer gas and similar gases, other than petroleum gases and other gaseous hydrocarbons	10.2%	6.5%	Free	Free	B
2706.00.00	Tar distilled from coal, from lignite or from peat, and other mineral tars, whether or not dehydrated or partially distilled, including reconstituted tars	Free	Free	Free	Free	D
27.07	Oils and other products of the distillation of high temperature coal tar; similar products in which the weight of the aromatic constituents exceeds that of the non-aromatic constituents					

2707.10.00	-Benzole	12.5%	8%	Free	Free	A
2707.20.00	-Toluole	12.5%	8%	Free	Free	A
2707.30.00	-Xylole	12.5%	8%	Free	Free	A
2707.40.00	-Naphthalene	12.5%	8%	Free	Free	A
2707.50.00	-Other aromatic hydrocarbon mixtures of which 65% or more by volume (including losses) distils at 250°C by the ASTM D 86 method	12.5%	8%	Free	Free	B
2707.60.00	-Phenols	12.5%	8%	2.9¢/kg +12.5%	Free	B
	-Other:					
2707.91.00	--Creosote oils	12.5%	8%	Free	Free	A
2707.99.00	--Other	12.5%	8%	(1)	(1)	B
27.08	Pitch and pitch coke, obtained from coal tar or from other mineral tars					
2708.10.00	-Pitch	Free	Free	Free	Free	D
2708.20.00	-Pitch coke	Free	Free	Free	Free	D
2709.00	Petroleum oils and oils obtained from bituminous minerals, crude					
2709.00.10	---Not subjected to any other process than natural weathering and the removal of foreign matter and water and having a relative density of 0.8156 (42° A.P.I.) or more at 15.6°C, for refining	Free	Free	5.25¢/bbl		B
2709.00.90	---Other	$1.10/m^3	$1.10/m^3	10.5¢/bbl		B
2710.00	Petroleum oils and oils obtained from bituminous minerals, other than crude; preparations not elsewhere specified or included, containing by weight 70% or more of petroleum oils or of oils obtained from bituminous minerals, these oils being the basic constituents of the preparations					
2710.00.10	---Alkylenes, mixed, with a very low degree of polymerization; lubricating oils or base-stocks, containing by weight more than 50% of synthetic hydrocarbons	12.5%	8%	10.5¢/bbl		C

CHAPTER 27 (cont'd)

Tariff Item	Description of Goods	Canada MFN	Canada GPT	United States MFN	United States GPT	Phase-Out in FTA
2710.00.20	---Other lubricating oils put up in packings for retail sale; oils and preparations thereof, having a viscosity of 7.44 mm²/sec. or more at 37.8°C, other than white oils	8%	5%	10.5¢/bbl		C
2710.00.30	---White oils	11.3%	7.5%	8.4¢/bbl		C
2710.00.40	---Petroleum greases and lubricating greases	12.5%	8%	1.3¢/kg + 5.7%		C
2710.00.90	---Other	Free	Free	7%	Free	B
27.11	Petroleum gases and other gaseous hydrocarbons					
	-Liquefied:					
2711.11.00	--Natural gas	12.5%	8%	Free	Free	A
2711.12	--Propane					
2711.12.10	---In containers ready for use	12.5%	8%	Free	Free	C
2711.12.90	---Other	Free	Free	Free	Free	D
2711.13.00	--Butanes	12.5%	8%	Free	Free	A
2711.14.00	--Ethylene, propylene, butylene and butadiene	12.5%	8%	Free	Free	A
2711.19	--Other					
2711.19.10	---In containers ready for use	12.5%	8%	Free	Free	C
2711.19.90	---Other	Free	Free	Free	Free	D
	-In gaseous state:					
2711.21.00	--Natural gas	Free	Free	Free	Free	D
2711.29.00	--Other	Free	Free	Free	Free	D
27.12	Petroleum jelly; paraffin wax, micro-crystalline petroleum wax, slack wax, ozokerite, lignite wax, peat wax, other mineral waxes, and similar products obtained by synthesis or by other processes, whether or not coloured					
2712.10.00	-Petroleum jelly	11.3%	7.5%	Free	Free	C
2712.20	-Paraffin wax containing by weight less than 0.75% of oil					
2712.20.10	---For use in the manufacture of candles	Free	Free	Free	Free	D
2712.20.90	---Other	10.2%	6.5%	Free	Free	C

2712.90	-Other					
2712.90.10	---Lignite (Montan) wax	Free	Free	Free	Free	D
2712.90.20	---Micro-crystalline petroleum wax	10.2%	6.5%	Free	Free	C
2712.90.90	---Other	5.5%	5.5%	Free	Free	C
27.13	Petroleum coke, petroleum bitumen and other residues of petroleum oils or of oils obtained from bituminous minerals					
	-Petroleum coke:					
2713.11.00	--Not calcined	Free	Free	Free	Free	D
2713.12.00	--Calcined	Free	Free	3%	Free	A
2713.20.00	-Petroleum bitumen	6.8%	Free	Free	Free	C
2713.90.00	-Other residues of petroleum oils or of oils obtained from bituminous minerals	Free	Free	Free	Free	D
27.14	Bitumen and asphalt, natural; bituminous or oil shale and tar sands; asphaltites and asphaltic rocks					
2714.10.00	-Bituminous or oil shale and tar sands	10.2%	6.5%	Free	Free	C
2714.90	-Other					
2714.90.10	---Gilsonite	Free	Free	Free	Free	D
2714.90.90	---Other	6.8%	Free	Free	Free	C
2715.00	Bituminous mixtures based on natural asphalt, on natural bitumen, on petroleum bitumen, on mineral tar or on mineral tar pitch (for example, bituminous mastics, cut-backs)					
2715.00.10	---Asphaltum oil of a kind used for paving purposes	Free	Free	Free	Free	D
2715.00.20	---Mastics of asphalt and other bituminous mastics	9.2%	6%	Free	Free	C
2715.00.90	---Other	6.8%	Free	Free	Free	C
2716.00.00	Electrical energy	Free	Free	Free	Free	D

CHAPTER 28. CHEMICAL ELEMENTS AND COMPOUNDS

Tariff Item	Description of Goods	Canada		United States		Phase-Out in FTA
		MFN	GPT	MFN	GPT	
2802.00.00	Sulphur, sublimed or precipitated; colloidal sulphur	Free	Free	Free	Free	D
2804.50.00	Tellurium	9.2%	6%	Free	Free	B
	-Silicon:					
2804.61.00	--Containing by weight not less than 99.99% of silicon	9.2%	6%	3.7%	Free	B
2804.69.10	--Containing by weight 99% to 99.99% of silicon	..	..	5.3%	Free	C
2804.69.00	--Other	9.2%	6%	9%	Free	C
2804.70.00	-Phosphorus	5%	Free	Free	Free	B
2804.80.00	-Arsenic	9.2%	6%	Free	Free	B
2804.90.00	-Selenium	9.2%	5%	Free	Free	B
28.05	Alkali or alkaline-earth metals; rare-earth metals, scandium and yttrium, whether or not intermixed or interalloyed; mercury					
	-Alkali metals:					
2805.11.00	--Sodium	Free	Free	5.3%	Free	B
2805.19.00	--Other (e.g., cesium, lithium, rubidium)	9.2%	6%	6.6%	Free	B
	-Alkaline-earth metals:					
2805.21.00	--Calcium	9.2%	6%	3%	Free	B
2805.22.10	--Strontium	9.2%	6%	3.7%	Free	B
2805.22.20	--Barium	9.2%	6%	Free	Free	B
2805.30.00	-Rare-earth metals, scandium and yttrium, whether or not intermixed or interalloyed	12.5%	8%	70.5¢/kg	Free	B

2805.40.00	-Mercury	Free	Free	14.1¢/kg	Free	B
2807.00.00	Sulphuric acid; oleum	Free	Free	Free	Free	D
2811.23.00	Sulphur dioxide	Free	Free	4.2%	Free	B
2817.00.00	Zinc oxide; zinc peroxide	10.5%	Free	Free	Free	C
28.18	Aluminum oxide (including artificial corundum)					
2818.10.00	-Artificial corundum	Free	Free	(1)	(1)	B,D
2818.20.00	-Other aluminum oxide	Free	Free	Free	Free	D
28.19	Chromium oxides and hydroxides					
2819.10.00	-Chromium trioxide	12.5%	8%	3.7%	Free	B
2819.90.00	-Other	12.5%	8%	3.7%	Free	B
28.20	Manganese oxides					
2820.10.00	-Manganese dioxide	Free	Free	4.7%	Free	B
2820.90.00	-Other	Free	Free	4.7%	Free	B
28.21	Iron oxides and hydroxides; earth colours containing 70% or more by weight of combined iron evaluated as Fe_2O_3					
2821.10.00	-Iron oxides and hydroxides	12.5%	8%	3.7%	Free	B
2821.20.00	-Earth colours	12.5%	8%	5.8%	Free	B
2822.00	Cobalt oxides and hydroxides; commercial cobalt oxides					
2822.00.10	---Cobalt hydroxides	Free	Free	2.6¢/kg	Free	B
2822.00.90	---Other	9.8%	Free	2.6¢/kg	Free	B
2823.00.00	Titanium oxides	10%	Free	6%	Free	C
28.24	Lead oxides; red lead and orange lead					
2824.10.00	-Lead monoxide (litharge, massicot)	12.5%	Free	2.4%	Free	B
2824.20.00	-Red lead and orange lead	10.5%	Free	3.4%	Free	B
2824.90.00	-Other	12.5%	Free	(1)	(1)	B

CHAPTER 28 (cont'd)

Tariff Item	Description of Goods	Canada		United States		Phase-Out in FTA
		MFN	GPT	MFN	GPT	
2825.20.00	Lithium oxide and hydroxide	Free	Free	3.7%	Free	B
2825.30.00	Vanadium oxides and hydroxides	Free	Free	16%	Free	B
2825.40.00	Nickel oxides and hydroxides	Free	Free	Free	Free	D
2825.50.00	Copper oxides and hydroxides	Free	Free	(1)	(1)	B
2825.60.00	Germanium oxides and zirconium dioxide	Free	Free	3.7%	Free	B
2825.70	Molybdenum oxides and hydroxides					
2825.70.10	--Molybdenum oxides	12.5%	8%	3.2%	Free	B
2825.70.20	--Molybdenum hydroxides	Free	Free	3.2%	Free	B
2825.80.00	Antimony oxides	Free	Free	Free	Free	D
2827.20.00	Calcium chloride	12.5%	8%	Free	Free	B
2836.50.00	-Calcium carbonate	12.5%	8%	Free	Free	D
2836.60.00	-Barium carbonate	Free	Free	0.9¢/kg	Free	B
2836.92.00	Strontium carbonate	12.5%	8%	4.2%	Free	B
2841.70.00	Molybdates	9.2%	6%	..	..	B
2841.70.10	--Of ammonia	..	..	4.3%	Free	B
2841.70.50	--Other	..	..	3.7%	Free	B
2841.80.00	-Tungstates (wolframates)	9.2%	6%	10%	Free	B
28.43	Colloidal precious metals; inorganic or organic compounds of precious metals, whether or not chemically defined; amalgams of precious metals					
2843.10.00	-Colloidal precious metals	12.5%	8%	6%	Free	B
	-Silver compounds:					
2843.21.00	--Silver nitrate	12.5%	8%	3.7%	Free	B
2843.29.00	--Other	12.5%	8%	3.7%	Free	B

2843.30.00	-Gold compounds	12.5%	8%	5%	Free	B
2843.90.00	-Other compounds; amalgams	12.5%	8%	3.7%	Free	B
28.44	Radioactive chemical elements and radioactive isotopes (including the fissile or fertile chemical elements and isotopes) and their compounds; mixtures and residues containing these products					
2844.10.00	-Natural uranium and its compounds; alloys, dispersions (including cermets), ceramic products and mixtures containing natural uranium or natural uranium compounds	Free	Free	(1)	(1)	B,D
2844.20.00	-Uranium enriched in U235 and its compounds; plutonium and its compounds; alloys, dispersions (including cermets), ceramic products and mixtures containing uranium enriched in U235, plutonium or compounds of these products	Free	Free	Free	Free	D
2844.30.00	-Uranium depleted in U235 and its compounds; thorium and its compounds; alloys, dispersions (including cermets), ceramic products and mixtures containing uranium depleted in U235, thorium or compounds of these products	Free	Free	(1)	(1)	B,D
2844.40.00	-Radioactive elements and isotopes and compounds other than those of subheading No. 2844.10, 2844.20 or 2844.30; alloys, dispersions (including cermets), ceramic products and mixtures containing these elements, isotopes or compounds; radioactive residues	Free	Free	Free	Free	D
2844.50.00	-Spent (irradiated) fuel elements (cartridges) of nuclear reactors	Free	Free	Free	Free	D
28.45	Isotopes other than those of heading No. 28.44; compounds, inorganic or organic, of such isotopes, whether or not chemically defined					
2845.10.00	-Heavy water (deuterium oxide)	Free	Free	Free	Free	D
2845.90.00	-Other	Free	Free	Free	Free	D

CHAPTER 28 (cont'd)

Tariff Item	Description of Goods	Canada		United States		Phase-Out in FTA
		MFN	GPT	MFN	GPT	
28.46	Compounds, inorganic or organic, of rare-earth metals, of yttrium or of scandium or of mixtures of these metals					
2846.10.00	-Cerium compounds	12.5%	8%	7.2%	Free	B
2846.90.00	-Other	12.5%	8%	(1)	(1)	B
28.49	Carbides, whether or not chemically defined					
2849.10.00	-Of calcium	10%	5%	1.8%	Free	B
2849.20.00	-Of silicon	Free	Free	..	..	D
2849.20.10	---Crude	..	..	Free	Free	D
2849.20.20	---In grains, ground, pulverized	..	..	0.7¢/kg	Free	B
2849.90.00	-Other	Free	Free	(1)	(1)	B

CHAPTER 31. FERTILIZERS

Tariff Item	Description of Goods	Canada MFN	Canada GPT	United States MFN	United States GPT	Phase-Out in FTA
3101.00.00	Animal or vegetable fertilizers, whether or not mixed together or chemically treated; fertilizers produced by the mixing or chemical treatment of animal or vegetable products	Free	Free	Free	Free	D
31.02	Mineral or chemical fertilizers, nitrogenous					
3102.10.00	-Urea, whether or not in aqueous solution	Free	Free	Free	Free	D
	-Ammonium sulphate; double salts and mixtures of ammonium sulphate and ammonium nitrate:					
3102.21.00	--Ammonium sulphate	Free	Free	Free	Free	D
3102.29.00	--Other	Free	Free	Free	Free	D
3102.30.00	-Ammonium nitrate, whether or not in aqueous solution	Free	Free	Free	Free	D
3102.40.00	-Mixtures of ammonium nitrate with calcium carbonate or other inorganic non-fertilizing substances	Free	Free	Free	Free	D
3102.50.00	-Sodium nitrate	Free	Free	Free	Free	D
3102.60.00	-Double salts and mixtures of calcium nitrate and ammonium nitrate	Free	Free	Free	Free	D
3102.70.00	-Calcium cyanamide	Free	Free	Free	Free	D
3102.80.00	-Mixtures of urea and ammonium nitrate in aqueous or ammoniacal solution	Free	Free	Free	Free	D
3102.90.00	-Other, including mixtures not specified in the foregoing subheadings	Free	Free	Free	Free	D
31.03	Mineral or chemical fertilizers, phosphatic					
3103.10.00	-Superphosphates	Free	Free	Free	Free	D
3103.20.00	-Basic slag	Free	Free	Free	Free	D
3103.90.00	-Other	Free	Free	Free	Free	D
31.04	Mineral or chemical fertilizers, potassic					

Tariff Item	Description of Goods	Canada		United States		Phase-Out in FTA
		MFN	GPT	MFN	GPT	
3104.10.00	-Carnallite, sylvite and other crude natural potassium salts	Free	Free	Free	Free	D
3104.20.00	-Potassium chloride	Free	Free	Free	Free	D
3104.30.00	-Potassium sulphate	Free	Free	Free	Free	D
3104.90.00	-Other	Free	Free	Free	Free	D
31.05	Mineral or chemical fertilizers containing two or three of the fertilizing elements nitrogen, phosphorus and potassium; other fertilizers; goods of this Chapter in tablets or similar forms or in packages of a gross weight not exceeding 10 kg					
3105.10.00	-Goods of this Chapter in tablets or similar forms or in packages of a gross weight not exceeding 10 kg	Free	Free	Free	Free	D
3105.20.00	-Mineral or chemical fertilizers containing the three fertilizing elements nitrogen, phosphorus and potassium	Free	Free	Free	Free	D
3105.30.00	-Diammonium hydrogenorthophosphate (diammonium phosphate)	Free	Free	Free	Free	D
3105.40.00	-Ammonium dihydrogenorthophosphate (monoammonium phosphate) and mixtures thereof with diammonium hydrogenorthophosphate (diammonium phosphate)	Free	Free	Free	Free	D
	-Other mineral or chemical fertilizers containing the two fertilizing elements nitrogen and phosphorus:					
3105.51.00	--Containing nitrates and phosphates	Free	Free	Free	Free	D
3105.59.00	--Other	Free	Free	Free	Free	D
3105.60.00	-Mineral or chemical fertilizers containing the two fertilizing elements phosphorus and potassium	Free	Free	Free	Free	D
3105.90.00	-Other	Free	Free	Free	Free	D

CHAPTER 32. PIGMENTS AND OTHER PREPARATIONS

Tariff Item	Description of Goods	Canada MFN	Canada GPT	United States MFN	United States GPT	Phase-Out in FTA
3206.10.00	Pigments and preparations based on titanium dioxide	10%	Free	6%	Free	B
3206.20.00	Pigments and preparations based on chromium compounds	12.5%	8%	3.7%	Free	B
3206.30.00	Pigments and preparations based on cadmium compounds	12.5%	8%	3.1%	Free	B
	Other colouring matter and other preparations:					
3206.41.00	--Ultramarine and preparations based thereon	8.5%	Free	1.5%	Free	B
3206.42.00	--Lithopone and other pigments and preparations based on zinc sulphide	10.5%	Free	2.2%	Free	B
3206.43.00	--Pigments and preparations based on hexacyanoferrates (ferrocyanides and ferricyanides)	12.5%	8%	3.7%	Free	B
3206.49	--Other	5 to 12.5%	Free to 8%	Free to 8.5%	Free	B

CHAPTER 68. ARTICLES OF STONE, PLASTER, CEMENT, ASBESTOS, MICA OR SIMILAR MATERIALS

Tariff Item	Description of Goods	Canada		United States		Phase-Out in FTA
		MFN	GPT	MFN	GPT	
6801.00.00	Setts, curbstones and flagstones, of natural stone (except slate)	5.5%	Free	4.2%	Free	B
68.02	Worked monumental or building stone (except slate) and articles thereof, other than goods of heading No. 68.01; mosaic cubes and the like, of natural stone (including slate), whether or not on a backing; artificially coloured granules, chippings and powder, of natural stone (including slate)					
6802.10	-Tiles, cubes and similar articles, whether or not rectangular (including square), the largest surface area of which is capable of being enclosed in a square the side of which is less than 7 cm; artificially coloured granules, chippings and powder					
6802.10.10	---Roofing granules, artificially coloured	Free	Free	6.9%	Free	B
6802.10.90	---Other	12.5%	8%	6.9%	Free	B
	-Other monumental or building stone and articles thereof, simply cut or sawn, with a flat or even surface:					
6802.21.00	--Marble, travertine and alabaster	5.7%	3.5%	(1)	(1)	B
6802.22.00	--Other calcareous stone	8%	5%	6%	Free	B
6802.23.00	--Granite	5.5%	Free	4.3%	Free	A
6802.29.00	--Other stone	8%	5%	7.5%	Free	B
	-Other:					
6802.91.00	--Marble, travertine and alabaster	9%	Free	(1)	(1)	B
6802.92.00	--Other calcareous stone	9.9%	6.5%	6%	Free	B
6802.93.00	--Granite	10.2%	6.5%	4.2%	Free	A
6802.99.00	--Other stone	10.2%	6.5%	6.5%	Free	B

6803.00	Worked slate and articles of slate of agglomerated slate					
6803.00.10	---Roofing slate	Free	Free	6.6%	Free	B
6803.00.90	---Other	10.2%	6.5%	3.7%	Free	B
68.04	Millstones, grindstones, grinding wheels and the like, without frameworks, for grinding, sharpening, polishing, trueing or cutting, hand sharpening or polishing stones, and parts thereof, of natural stone, of agglomerated natural or artificial abrasives, or of ceramics, with or without parts of other materials					
6804.10.00	-Millstones and grindstones for milling, grinding or pulping	10.2%	Free	Free	Free	C
	-Other millstones, grindstones, grinding wheels and the like:					
6804.21.00	--Of agglomerated synthetic or natural diamond	10.2%	6.5%	4.9%	Free	C
6804.22.00	--Of other agglomerated abrasives or of ceramics	10.2%	6.5%	(1)	(1)	C
6804.23.00	--Of natural stone	10.2%	Free	Free	Free	C
6804.30.00	-Hand sharpening or polishing stones	10.2%	6.5%	Free	Free	C
68.05	Natural or artificial abrasive powder or grain, on a base of textile material, of paper, of paperboard or of other materials, whether or not cut to shape or sewn or otherwise made up					
6805.10.00	-On a base of woven textile fabric only	10.2%	6.5%	2.5%	Free	C
6805.20.00	-On a base of paper or paperboard only	10.2%	6.5%	2.5%	Free	C
6805.30.00	-On a base of other materials	10.2%	6.5%	2.5%	Free	C
68.06	Slag wool, rock wool and similar mineral wools; exfoliated vermiculite, expanded clays, foamed slag and similar expanded mineral materials; mixtures and articles of heat-insulating, sound-insulating or sound-absorbing mineral materials, other than those of heading No. 68.11 or 68.12 or of Chapter 69					

CHAPTER 68 (cont'd)

Tariff Item	Description of Goods	Canada		United States		Phase-Out in FTA
		MFN	GPT	MFN	GPT	
6806.10	-Slag wool, rock wool and similar mineral wools, (including intermixtures thereof) in bulk, sheets or rolls					
6806.10.10	---Sheathing, containing vegetable fibres, in rolls	6.5%	Free	4.9%	Free	B
6806.10.20	---Alumino-silicate refractory fibres	10.2%	6.5%	4.9%	Free	B
6806.10.90	---Other	11.3%	Free	4.9%	Free	B
6806.20.00	-Exfoliated vermiculite, expanded clays, foamed slag and similar expanded mineral materials (including intermixtures thereof)	10.2%	6.5%	4.9%	Free	B
6806.90	-Other					
6806.90.10	---Sheathing, containing vegetable fibres	6.5%	Free	4.9%	Free	B
6806.90.20	---Articles of alumino-silicate refractory fibres	10.2%	6.5%	4.9%	Free	B
6806.90.90	---Other	9.6%	6%	4.9%	Free	B
68.07	Articles of asphalt or of similar material (for example, petroleum bitumen or coal tar pitch)					
6807.10.00	-In rolls	10.2%	6.5%	4.9%	Free	B
6807.90.00	-Other	10.2%	6.5%	5.3%	Free	B
6808.00	Panels, boards, tiles, blocks and similar articles of vegetable fibre, of straw or of shavings, chips, particles, sawdust or other waste, of wood, agglomerated with cement, plaster or other mineral binders					
6808.00.10	---Tiles and lay-in panels, for ceilings, in rectangular sheets of 43 cm by 56 cm or more	6.5%	4%	Free	Free	C
6808.00.90	---Other	9.2%	Free	Free	Free	C
68.09	Articles of plaster or of compositions based on plaster					
	-Boards, sheets, panels, tiles and similar articles, not ornamented:					

6809.11	--Faced or reinforced with paper or paperboard only					
6809.11.10	---Gypsum wallboard	9.4%	Free	2.4%	Free	C
6809.11.90	---Other	9.2%	Free	2.4%	Free	C
6809.19.00	--Other	10.2%	6%	6%	Free	C
6809.90	-Other articles					
6809.90.10	---Models and casts, of a kind used in the manufacture of dental prostheses	Free	Free	5%	Free	C
6809.90.90	---Other	10.2%	6.5%	5%	Free	C
68.10	Articles of cement, of concrete or of artificial stone, whether or not reinforced					
	-Tiles, flagstones, bricks and similar articles:					
6810.11.00	--Building blocks and bricks	5%	Free	4.9%	Free	B
6810.19.00	--Other	8%	Free	(1)	(1)	B
6810.20.00	-Pipes	9.8%	6.5%	4.9%	Free	B
	-Other articles:					
6810.91	--Prefabricated structural components for building or civil engineering					
6810.91.10	---For silos	6.8%	4.5%	4.9%	Free	B
6810.91.90	---Other	8%	Free	4.9%	Free	B
6810.99.00	--Other	8%	Free	4.9%	Free	B
68.11	Articles of asbestos-cement, of cellulose fibre-cement or the like					
6811.10.00	-Corrugated sheets	8%	5%	Free	Free	B
6811.20.00	-Other sheets, panels, tiles and similar articles	8%	5%	Free	Free	B
6811.30.00	-Tubes, pipes and tube or pipe fittings	8%	5%	0.3¢/kg	Free	B
6811.90.00	-Other articles	8%	5%	Free	Free	B

CHAPTER 68 (cont'd)

Tariff Item	Description of Goods	Canada		United States		Phase-Out in FTA
		MFN	GPT	MFN	GPT	
68.12	Fabricated asbestos fibres; mixtures with a basis of asbestos or with a basis of asbestos and magnesium carbonate; articles of such mixtures or of asbestos (for example, thread, woven fabric, clothing, headgear, footwear, gaskets), whether or not reinforced, other than goods of heading No. 68.11 or 68.13					
6812.10.00	-Fabricated asbestos fibres; mixtures with a basis of asbestos or with a basis of asbestos and magnesium carbonate	8%	5%	Free	Free	B
6812.20.00	-Yarn and thread	12.5%	12.5%	Free	Free	B
6812.30.00	-Cords and string, whether or not plaited	12.5%	12.5%	Free	Free	B
6812.40.00	-Woven or knitted fabric	25%	25%	Free	Free	B
6812.50.00	-Clothing, clothing accessories, footwear and headgear	25%	25%	(1)	(1)	B
6812.60.00	-Paper, millboard and felt	8%	5%	Free	Free	B
6812.70.00	-Compressed asbestos fibre jointing, in sheets or rolls	8%	5%	Free	Free	B
6812.90	-Other					
6812.90.10	---Belting	17.5%	7.5%	Free	Free	B
6812.90.90	---Other	8%	5%	Free	Free	B
68.13	Friction material and articles thereof (for example, sheets, rolls, strips, segments, discs, washers, pads), not mounted, for brakes, for clutches or the like, with a basis of asbestos, of other mineral substances or of cellulose, whether or not combined with textile or other materials					
6813.10	-Brake linings and pads					
6813.10.10	---For motor vehicles of heading No. 87.02, 87.03, 87.04 or 87.05	11.3%	Free	Free	Free	C

6813.10.90	---Other	8%	5%	Free	Free	C
6813.90	-Other					
6813.90.10	---Clutch facings for motor vehicles of heading No. 87.02, 87.03, 87.04 or 87.05	11.3%	7.5%	Free	Free	C
6813.90.90	---Other	9.2%	2.5%	Free	Free	C
68.14	Worked mica and articles of mica, including agglomerated or reconstituted mica, whether or not on a support of paper, paperboard or other materials					
6814.10.00	-Plates, sheets and strips of agglomerated or reconstituted mica, whether or not on a support	10.2%	6.5%	5.3%	Free	B
6814.90.00	-Other	10.2%	6.5%	5.1%	Free	B
68.15	Articles of stone or of other mineral substances (including articles of peat), not elsewhere specified or included					
6815.10	-Non-electrical articles of graphite or other carbon					
6815.10.10	---Graphite blocks of a diameter exceeding 1 m and a thickness exceeding 38 cm used for making moulds for casting wheels for railway vehicles	5%	Free	4.9%	Free	C
6815.10.90	---Other	9.2%	6%	4.9%	Free	C
6815.20.00	-Articles of peat	6.8%	4.5%	Free	Free	C
	-Other articles:					
6815.91.00	--Containing magnesite, dolomite or chromite	10.2%	6.5%	4.9%	Free	C
6815.99	--Other					
6815.99.10	---Models and casts, of a kind used in the manufacture of dental prostheses	Free	Free	Free	Free	D
6815.99.20	---Foundry facings	9.2%	6%	Free	Free	C
6815.99.30	---Signs	11.3%	7.5%	Free	Free	C
6815.99.40	---Cast articles of basalt	5%	Free	4.5%	Free	C
	---Other articles:					
6815.99.91	----Of clay or cement	8%	Free	(1)	(1)	C
6815.99.99	----Other	10.2%	6.5%	(1)	(1)	C

CHAPTER 69. CERAMIC PRODUCTS

Tariff Item	Description of Goods	Canada		United States		Phase-Out in FTA
		MFN	GPT	MFN	GPT	
	I - GOODS OF SILICEOUS FOSSIL MEALS OR OF SIMILAR SILICEOUS EARTHS, AND REFRACTORY GOODS					
6901.00.00	Bricks, blocks, tiles and other ceramic goods of siliceous fossil meals (for example, kieselguhr, tripolite or diatomite) or of similar siliceous earths	Free	Free	4.9%	Free	B
69.02	Refractory bricks, blocks, tiles and similar refractory ceramic constructional goods, other than those of siliceous fossil meals or similar siliceous earths					
6902.10.00	-Containing by weight, singly or together, more than 50% of the elements Mg, Ca or Cr, expressed as MgO, CaO or Cr_2O_3	Free	Free	(1)	(1)	B,D
6902.20.00	-Containing by weight more than 50% of alumina (Al_2O_3), of silica (SiO_2) or of a mixture or compound of these products	Free	Free	(1)	(1)	B,D
6902.90	-Other					
6902.90.10	---Containing by weight 85% or more of carbon or graphite	6.8%	4.5%	Free	Free	C
6902.90.90	---Other	Free	Free	(1)	(1)	C,D
69.03	Other refractory ceramic goods (for example, retorts, crucibles, muffles, nozzles, plugs, supports, cupels, tubes, pipes, sheaths and rods), other than those of siliceous fossil meals or of similar siliceous earths					
6903.10	-Containing by weight more than 50% of graphite or other forms of carbon or of a mixture of these products					
6903.10.10	---Crucibles and covers therefor	6.8%	Free	4.9%	Free	C
6903.10.90	---Other	9.2%	6%	4.9%	Free	C
6903.20	-Containing by weight more than 50% of alumina (Al_2O_3) or of a mixture or compound of alumina and of silica (SiO_2)					

6903.20.10	---Supports namely: saggers, hillers, bats and plate setters	Free	Free	4.9%	Free	C
6903.20.20	---Crucibles and covers therefor	6.8%	Free	4.9%	Free	C
6903.20.90	---Other	11.3%	7.5%	4.9%	Free	C
6903.90	-Other					
6903.90.10	---Supports namely: saggers, hillers, bats and plate setters	Free	Free	4.9%	Free	C
6903.90.20	---Crucibles and covers therefor	6.8%	Free	4.9%	Free	C
6903.90.90	---Other	11.3%	7.5%	4.9%	Free	C

II - OTHER CERAMIC PRODUCTS

69.04	Ceramic building bricks, flooring blocks, support or filler tiles and the like					
6904.10.00	-Building bricks	5%	Free	Free	Free	B
6904.90	-Other					
6904.90.10	---Flooring blocks	5%	Free	4.9%	Free	B
6904.90.20	---Support or filler tiles and the like	12.5%	8%			
69.05	Roofing tiles, chimney-pots, cowls, chimney liners, architectural ornaments and other ceramic constructional goods					
6905.10.00	-Roofing tiles	10.2%	Free	13.5%	Free	B
6905.90.00	-Other	11.3%	7.5%	4.9%	Free	B
6906.00.00	Ceramic pipes, conduits, guttering and pipe fittings	11.3%	7.5%	4.9%	Free	B
69.07	Unglazed ceramic flags and paving, hearth or wall tiles; unglazed ceramic mosaic cubes and the like, whether or not on a backing					
6907.10.00	-Tiles, cubes and similar articles, whether or not rectangular, the largest surface area of which is capable of being enclosed in a square the side of which is less than 7 cm	12.5%	8%	20%	Free	C

Tariff Item	Description of Goods	Canada		United States		Phase-Out in FTA
		MFN	GPT	MFN	GPT	
6907.90.00	-Other	12.5%	8%	20%	Free	C
69.08	Glazed ceramic flags and paving, hearth or wall tiles; glazed ceramic mosaic cubes and the like, whether or not on a backing					
6908.10.00	-Tiles, cubes and similar articles, whether or not rectangular, the largest surface area of which is capable of being enclosed in a square the side of which is less than 7 cm	12.5%	8%	20%	Free	C
6908.90.00	-Other	12.5%	8%	19%	Free	C

CHAPTER 71. PRECIOUS OR SEMI-PRECIOUS STONES, PRECIOUS METALS

Tariff Item	Description of Goods	Canada MFN	Canada GPT	United States MFN	United States GPT	Phase-Out in FTA
	I - PRECIOUS OR SEMI-PRECIOUS STONES					
71.02	Diamonds, whether or not worked, but not mounted or set					
7102.10.00	-Unsorted	Free	Free	Free	Free	D
	-Industrial:					
7102.21	--Unworked or simply sawn, cleaved or bruted					
7102.21.10	---Bort and black diamonds, for borers	Free	Free	Free	Free	D
7102.21.90	---Other	10.2%	6.5%	(1)	(1)	B
7102.29	--Other					
7102.29.10	---Bort and black diamonds, for borers	Free	Free	Free	Free	D
7102.29.90	---Other	10.2%	6.5%	Free	Free	D
	-Non-industrial:					
7102.31.00	--Unworked or simply sawn, cleaved or bruted	Free	Free	Free	Free	D
7102.39.00	--Other	Free	Free	Free	Free	D
71.03	Precious stones (other than diamonds) and semi-precious stones, whether or not worked or graded but not strung, mounted or set; ungraded precious stones (other than diamonds) and semi-precious stones, temporarily strung for convenience of transport					
7103.10.00	-Unworked or simply sawn or roughly shaped	Free	Free	(1)	(1)	B,D
	-Otherwise worked:					
7103.91.00	-Rubies, sapphires and emeralds	Free	Free	Free	Free	D
7103.99.00	--Other	Free	Free	(1)	(1)	A,B

Tariff Item	Description of Goods	Canada MFN	Canada GPT	United States MFN	United States GPT	Phase-Out in FTA
71.04	Synthetic or reconstructed precious or semi-precious stones, whether or not worked or graded but not strung, mounted or set; ungraded synthetic or reconstructed precious or semi-precious stones, temporarily strung for convenience of transport					
7104.10.00	-Piezo-electric quartz	Free	Free	6%	Free	B
7104.20.00	-Other, unworked or simply sawn or roughly shaped	Free	Free	6%	Free	B
7104.90.00	-Other	Free	Free	(1)	(1)	A,B
71.05	Dust and powder of natural or synthetic precious or semi-precious stones					
7105.10	-Of diamonds					
7105.10.10	---Dust for borers; dust mixed with a carrier in cartridges or in tubes	Free	Free	Free	Free	D
7105.10.90	---Other	10.2%	6.5%	Free	Free	D
7105.90.00	-Other	Free	Free	0.7¢/kg	Free	A

II - PRECIOUS METALS

Tariff Item	Description of Goods	Canada MFN	Canada GPT	United States MFN	United States GPT	Phase-Out in FTA
71.06	Silver, unwrought or in powder form					
7106.10	-Powder					
7106.10.10	---Containing by weight 92.5% or more of silver	4%	Free	Free	Free	D
7106.10.20	---Containing by weight less than 92.5% of silver	10.2%	6.5%	Free	Free	D
	-Other:					
7106.91	--Unwrought					
7106.91.10	---Containing by weight 92.5% or more of silver	Free	Free	Free	Free	D
7106.91.20	---Containing by weight less than 92.5% of silver	10.2%	6.5%	(1)	(1)	B

71.08	Gold, unwrought or in powder form					
	-Non-monetary:					
7108.11.00	--Powder	11%	7%	Free	Free	D
7108.12.00	--Other unwrought forms	Free	Free	(1)	(1)	B,D
7108.20.00	-Monetary	Free	Free	Free	Free	D
71.10	Platinum group metals					
	-Platinum:					
7110.11.00	--Unwrought or in powder form	Free	Free	Free	Free	D
	-Palladium:					
7110.21.00	--Unwrought or in powder form	Free	Free	Free	Free	D
	-Rhodium:					
7110.31.00	--Unwrought or in powder form	Free	Free	Free	Free	D
	-Iridium, osmium and ruthenium:					
7110.41.00	--Unwrought or in powder form	Free	Free	Free	Free	D
71.12	Waste and scrap of precious metal or of metal clad with precious metal					
7112.10.00	-Of gold, including metal clad with gold but excluding sweepings containing other precious metals	Free	Free	Free	Free	D
7112.20.00	-Of platinum, including metal clad with platinum but excluding sweepings containing other precious metals	Free	Free	Free	Free	D
7112.90.00	-Other	Free	Free	Free	Free	D

CHAPTER 72. IRON AND STEEL

Tariff Item	Description of Goods	Canada		United States		Phase-Out in FTA
		MFN	GPT	MFN	GPT	
72.01	Pig iron and spiegeleisen in pigs, blocks or other primary forms					
7201.10.00	-Non-alloy pig iron containing by weight 0.5% or less of phosphorus	Free	Free	Free	Free	D
7201.20.00	-Non-alloy pig iron containing by weight more than 0.5% of phosphorus	Free	Free	Free	Free	D
7201.30.00	-Alloy pig iron	Free	Free	Free	Free	D
7201.40.00	-Spiegeleisen	0.88¢/kg Mn	Free	0.2%	Free	A
72.02	Ferro-alloys					
	-Ferro-manganese:					
7202.11	--Containing by weight more than 2% of carbon					
7202.11.10	---Containing by weight not more than 1% of silicon	0.88¢/kg Mn	Free	1.4%	Free	A
7202.11.20	---Containing by weight more than 1% of silicon	1.54¢/kg Mn	Free	(1)	(1)	A
7202.19	--Other					
7202.19.10	---Containing by weight not more than 1% of silicon	0.88¢/kg Mn	Free	2.3%	Free	A
7202.19.20	---Containing by weight more than 1% of silicon	1.54¢/kg Mn	Free	(1)	(1)	A
	-Ferro-silicon:					
7202.21	--Containing by weight more than 55% of silicon					
7202.21.10	---Containing by weight less than 60% of silicon	Free	Free	1.1%	Free	A
7202.21.20	---Containing by weight 60% or more of silicon but less than 90%	1.54¢/kg Si	Free	1.5%	Free	A

7202.21.30	---Containing by weight 90% or more of silicon	4.41¢/kg Si	Free	1.9%	Free	A
7202.29.00	--Other	Free	Free	Free	Free	D
7202.30.00	Ferro-silico-manganese	1.54¢/kg Mn	Free	3.9%	Free	A
	-Ferro-chromium:					
7202.41.00	--Containing by weight more than 4% of carbon	10.2%	6.5%	1.9%	Free	A
7202.49.00	--Other	10.2%	6.5%	(1)	(1)	A
7202.50.00	-Ferro-silico-chromium	10.2%	6.5%	10%	Free	A
7202.60.00	-Ferro-nickel	10.2%	6.5%	Free	Free	A
7202.70.00	-Ferro-molybdenum	10.2%	6.5%	4.5%	Free	B
7202.80.00	-Ferro-tungsten and ferro-silico-tungsten	10.2%	6.5%	5.6%	Free	B
	-Other:					
7202.91.00	--Ferro-titanium and ferro-silico-titanium	10.2%	6.5%	3.7%	Free	B
7202.92.00	--Ferro-vanadium	10.2%	6.5%	4.2%	Free	B
7202.93.00	--Ferro-niobium	10.2%	6.5%	5%	Free	B
7202.99.10	--Ferro-zirconium	10.2%	6.5%	4.2%	Free	B
7202.99.50	--Other	10.2%	6.5%	5.0%	Free	A
72.03	Ferrous products obtained by direct reduction of iron ore and other spongy ferrous products, in lumps, pellets or similar forms; iron having a minimum purity by weight of 99.94%, in lumps, pellets or similar forms					
7203.10.00	-Ferrous products obtained by direct reduction of iron ore	Free	Free	Free	Free	D
7203.90.00	-Other	4%	Free	Free	Free	D
72.04	Ferrous waste and scrap; remelting scrap ingots of iron or steel					
7204.10.00	-Waste and scrap of cast iron	Free	Free	Free	Free	D

CHAPTER 72 (cont'd)

Tariff Item	Description of Goods	Canada		United States		Phase-Out in FTA
		MFN	GPT	MFN	GPT	
	-Waste and scrap of alloy steel:					
7204.21.00	--Of stainless steel	Free	Free	Free	Free	D
7204.29.00	--Other	Free	Free	Free	Free	D
7204.30.00	-Waste and scrap of tinned iron or steel	Free	Free	Free	Free	D
	-Other waste and scrap:					
7204.41.00	--Turnings, shavings, chips, milling waste, sawdust, filings, trimmings and stampings, whether or not in bundles	Free	Free	Free	Free	D
7204.49.00	--Other	Free	Free	Free	Free	D
7204.50.00	-Remelting scrap ingots	Free	Free	Free	Free	D
72.05	Granules and powders, of pig iron, spiegeleisen, iron or steel					
7205.10	-Granules					
	---Shot:					
7205.10.11	----Of steel, of a diameter not exceeding 9.5 mm, for burnishing	7.5%	Free	1%	Free	C
7205.10.19	----Other	10.2%	6.5%	1%	Free	C
7205.10.90	---Other	8.9%	5.5%	1%	Free	C
	-Powders:					
7205.21	--Of alloy steel					
7205.21.10	---Stainless steel powders to be employed as a filter media in the spinneret pack used in the production of man-made fibres	Free	Free	4%	Free	C
7205.21.90	---Other	10.2%	6.5%	4%	Free	C
7205.29.00	--Other	4%	Free	Free	Free	B
72.06	Iron and non-alloy steel in ingots or other primary forms (excluding iron of heading No. 72.03)					
7206.10.00	-Ingots	Free	Free	4.2%	Free	C
7206.90.00	-Other	4%	Free	4.2%	Free	C

CHAPTER 74. COPPER

Tariff Item	Description of Goods	Canada MFN	Canada GPT	United States MFN	United States GPT	Phase-Out in FTA
74.01	Copper mattes; cement copper (precipitated copper)					
7401.10.00	-Copper mattes	Free	Free	0.7¢/kg on Cu +0.7¢/kg Pb	Free	B
7401.20.00	-Cement copper (precipitated copper)	Free	Free	1.7% on Cu	Free	B
7402.00.00	Unrefined copper; copper anodes for electrolytic refining	Free	Free	1% on Cu	Free	B
74.03	Refined copper and copper alloys, unwrought					
	-Refined copper:					
7403.11.00	--Cathodes and sections of cathodes	Free	Free	1%	Free	B
7403.12.00	--Wire-bars	4%	Free	1%	Free	B
7403.13.00	--Billets	Free	Free	1%	Free	B
7403.19	--Other					
7403.19.10	---Ingots, ingot-bars and slabs	Free	Free	1%	Free	B
7403.19.90	---Other	10.3%	6.5%	1%	Free	B
	-Copper alloys:					
7403.21	--Copper-zinc base alloys (brass)					
7403.21.10	---Ingots, ingot-bars, slabs and billets	4%	Free	1%	Free	B
7403.21.90	---Other	10.3%	6.5%	1%	Free	B
7403.22.00	--Copper-tin base alloys (bronze)	10.3%	6.5%	1%	Free	B
7403.23	--Copper-nickel base alloys (cupro-nickel) or copper-nickel-zinc base alloys (nickel silver)					
7403.23.10	---Ingots, ingot-bars, slabs and billets	Free	Free	1%	Free	B
7403.23.90	---Other	10.3%	6.5%	1%	Free	B
7403.29	--Other copper alloys (other than master alloys of heading No. 74.05)					
7403.29.10	---Copper beryllium or copper phosphor alloys	4%	Free	1%	Free	B
7403.29.90	---Other	10.2%	6.5%	1%	Free	B

Tariff Item	Description of Goods	Canada		United States		Phase-Out in FTA
		MFN	GPT	MFN	GPT	
7404.00	Copper waste and scrap					
7404.00.10	---Not alloyed	Free	Free	Free	Free	D
	---Alloyed:					
7404.00.21	----Copper-zinc base alloys (brass)	4%	Free	Free	Free	B
7404.00.29	----Other	10.2%	6.5%	Free	Free	B
7405.00.00	Master alloys of copper	10.3%	6.5%	6%	Free	B
74.06	Copper powders and flakes					
7406.10	-Powders of non-lamellar structure					
7406.10.10	---Not alloyed	4%	Free	5.4%	Free	C
7406.10.20	---Alloyed	10.6%	7%	5.4%	Free	C
7406.20	-Powders of lamellar structure; flakes					
7406.20.10	---Not alloyed	4%	Free	3%	Free	C
7406.20.20	---Alloyed	10.6%	7%	3%	Free	C

CHAPTER 75. NICKEL

Tariff Item	Description of Goods	Canada		United States		Phase-Out in FTA
		MFN	GPT	MFN	GPT	
75.01	Nickel mattes, nickel oxide sinters and other intermediate products of nickel metallurgy					
7501.10.00	-Nickel mattes	Free	Free	Free	Free	D
7501.20.00	-Nickel oxide sinters and other intermediate products of nickel metallurgy	Free	Free	Free	Free	D
75.02	Unwrought nickel					
7502.10.00	-Nickel, not alloyed	Free	Free	Free	Free	D
7502.20.00	-Nickel alloys	Free	Free	Free	Free	D
7503.00.00	Nickel waste and scrap	Free	Free	Free	Free	D
7504.00	Nickel powders and flakes					
7504.00.10	---Powders, containing by weight 60% or more of nickel	Free	Free	Free	Free	D
7504.00.20	---Powders, containing by weight less than 60% of nickel; flakes	10.2%	6.5%	Free	Free	B

CHAPTER 76. ALUMINUM

Tariff Item	Description of Goods	Canada		United States		Phase-Out in FTA
		MFN	GPT	MFN	GPT	
76.01	Unwrought aluminum					
7601.10	-Aluminum, not alloyed					
7601.10.10	---Billets, blocks, ingots, notched bars, pigs, slabs and wire bars	Free	Free	(1)	(1)	A,D
	---Other:					
7601.10.91	----Granules, cut from ingots, for use in the manufacture of cleaning compounds	1.98¢/kg	Free	(1)	(1)	A
7601.10.99	----Other	10.3%	6.5%	(1)	(1)	A
7601.20	-Aluminum alloys					
7601.20.10	---Billets, blocks, ingots, notched bars, pigs, slabs and wire bars	Free	Free	(1)	(1)	A,D
	---Other:					
7601.20.91	----Granules, cut from ingots, for use in the manufacture of cleaning compounds	1.98¢/kg	Free	(1)	(1)	A
7601.20.99	----Other	10.3%	6.5%	(1)	(1)	A
7602.00.00	Aluminum waste and scrap	Free	Free	Free	Free	D
76.03	Aluminum powders and flakes					
7603.10.00	-Powders of non-lamellar structure	9.2%	Free	5.7%	Free	B
7603.20	-Powders of lamellar structure; flakes					
7603.20.10	---Powders	9.2%	Free	3.9%	Free	B
7603.20.20	---Flakes	10.3%	6.5%	3.9%	Free	B
76.04	Aluminum bars, rods and profiles					
7604.10	-Not alloyed, unworked:					
7604.10.11	---Bars and rods, min. c/s 12.7 mm	2.1%	Free	(1)	(1)	B
7604.11.12	---Bars and rods, max. c/s 12.7 mm	8%	Free	(1)	(1)	B
7604.21	-Alloyed, unworked					
7604.21.10	---Hollow profiles	8%	Free	(1)	(1)	B
7604.29.11	---Bars and rods, min. c/s 12.7 mm	2.1%	Free	(1)	(1)	B
7604.29.12	---Bars and rods, max. c/s 12.7 mm	8%	Free	(1)	(1)	B

CHAPTER 78. LEAD

Tariff Item	Description of Goods	Canada MFN	Canada GPT	United States MFN	United States GPT	Phase-Out in FTA
78.01	Unwrought lead					
7801.10	-Refined lead					
7801.10.10	---Pig and block	Free	Free	3.5% on Pb	Free	C
7801.10.90	---Other	10.2%	Free	3.5% on Pb	Free	C
	-Other:					
7801.91	--Containing by weight antimony as the principal other element					
7801.91.10	---Lead-antimony-tin alloys	6.8%	Free	3.5% on Pb	Free	C
7801.91.90	---Other	10.2%	Free	3.5% on Pb	Free	C
7801.99.00	--Other	10.2%	Free	3.5% on Pb	Free	C
7802.00.00	Lead waste and scrap	Free	Free	2.3% on Pb	Free	A
7804.20	-Powders and flakes					
7804.20.10	---Powders, not alloyed	4%	Free	11.25%	Free	C
7804.20.20	---Alloyed powders; flakes	10.2%	Free	11.25%	Free	C

CHAPTER 79. ZINC

Tariff Item	Description of Goods	Canada		United States		Phase-Out in FTA
		MFN	GPT	MFN	GPT	
79.01	Unwrought zinc					
	-Zinc, not alloyed:					
7901.11.00	--Containing by weight 99.99% or more of zinc	Free	Free	1.5%	Free	C
7901.12.00	--Containing by weight less than 99.99% of zinc	Free	Free	(1)	(1)	C
7901.20	-Zinc alloys					
7901.20.10	---Containing by weight 90% or more but less than 97.5% of zinc	Free	Free	19%	Free	
7901.20.20	---Containing by weight less than 90% of zinc	17.5%	11.5%	19%	Free	C
7902.00.00	Zinc waste and scrap	Free	Free	Free	Free	D
79.03	Zinc dust, powders and flakes					
7903.10.00	-Zinc dust	Free	Free	0.7¢/kg	Free	C
7903.90	-Other					
7903.90.10	---Powders, not alloyed	4%	Free	(1)	(1)	C
7903.90.20	---Alloyed powders; flakes	10.2%	6.5%	(1)	(1)	C

CHAPTER 80. TIN

Tariff Item	Description of Goods	Canada		United States		Phase-Out in FTA
		MFN	GPT	MFN	GPT	
80.01	Unwrought tin					
8001.10.00	-Tin, not alloyed	Free	Free	Free	Free	D
8001.20	-Tin alloys					
8001.20.10	---Tin-antimony alloys	Free	Free	Free	Free	D
8001.20.20	---Tin-lead-antimony alloys	6.8%	Free	Free	Free	A
8001.20.90	---Other	10.2%	6.5%	Free	Free	A
8002.00.00	Tin waste and scrap	Free	Free	Free	Free	D
8005.20	-Powders and flakes					
8005.20.10	---Powders, not alloyed	4%	Free	4.2%	Free	B
8005.20.20	---Alloyed powders; flakes	10.2%	6.5%	4.2%	Free	B

CHAPTER 81. OTHER BASE METALS

Tariff Item	Description of Goods	Canada		United States		Phase-Out in FTA
		MFN	GPT	MFN	GPT	
81.01	Tungsten (wolfram), including waste and scrap					
8101.10	-Powders					
8101.10.10	---Not alloyed	4%	Free	10.5%	Free	B
8101.10.20	---Alloyed	10.2%	6.5%	10.5%	Free	B
	-Other:					
8101.91	--Unwrought tungsten, including bars and rods obtained simply by sintering; waste and scrap					
8101.91.10	---Sintered bars and rods, not alloyed	Free	Free	4.2%	Free	B
	---Other:					
8101.91.91	----Unwrought tungsten, not alloyed	4%	Free	6.6%	Free	B
8101.91.92	----Unwrought tungsten, alloyed; waste and scrap	10.2%	6.5%	6.6%	Free	B
81.02	Molybdenum, including waste and scrap					
8102.10	-Powders					
8102.10.10	---Not alloyed	4%	Free	13.9%/kg Mo +1.9%	Free	B
8102.10.20	---Alloyed	10.2%	6.5%	13.9%/kg Mo +1.9%	Free	B
	-Other:					
8102.91	--Unwrought molybdenum, including bars and rods obtained simply by sintering; waste and scrap					
8102.91.10	---Unwrought molybdenum, not alloyed	4%	Free	13.9%/kg Mo +1.9%	Free	B
8102.91.20	---Unwrought molybdenum, alloyed; waste and scrap	10.2%	6.5%	13.9%/kg Mo +1.9%	Free	B
81.03	Tantalum and articles thereof, including waste and scrap					
8103.10	-Unwrought tantalum, including bars and rods obtained simply by sintering; waste and scrap; powders					
8103.10.10	---Unwrought tantalum, not alloyed; powders, not alloyed	4%	Free	Free	Free	B

8103.10.20	---Unwrought tantalum, alloyed; waste and scrap; powders, alloyed	10.2%	6.5%	Free	Free	B
81.04	Magnesium including waste and scrap					
	-Unwrought magnesium					
8104.11.00	--Containing at least 99.8% by weight of magnesium	4%	2.5%	8%	Free	C
8104.19.00	--Other	4%	Free	6.5%	Free	C
8104.20.00	-Waste and scrap	Free	Free	Free	Free	D
8104.30	-Raspings, turnings and granules, graded according to size; powders					
8104.30.10	---Raspings, turnings and granules; powders, alloyed	10.2%	6.5%	6.5%	Free	C
8104.30.20	---Powders, not alloyed	4%	2.5%	6.5%	Free	C
81.05	Cobalt mattes and other intermediate products of cobalt metallurgy, including waste and scrap					
8105.10	-Cobalt mattes and other intermediate products of cobalt metallurgy; unwrought cobalt; waste and scrap; powders					
8105.10.10	---Mattes and other intermediate products; unwrought cobalt, alloyed; waste and scrap; powders, alloyed	10.2%	6.5%	(1)	(1)	B
8105.10.20	---Unwrought cobalt, not alloyed; powders, not alloyed	Free	Free	(1)	(1)	B,D
8106.00	Bismuth, including waste and scrap					
8106.00.10	---Unwrought bismuth, not alloyed; powders, not alloyed	Free	Free	Free	Free	D
8106.00.20	---Unwrought bismuth, alloyed; waste and scrap; powders, alloyed	10.2%	6.5%	Free	Free	B
81.07	Cadmium, including waste and scrap					
8107.10	-Unwrought cadmium; waste and scrap; powders					
8107.10.10	---Unwrought cadmium, not alloyed; powders, not alloyed	Free	Free	Free	Free	D
8107.10.20	---Unwrought cadmium, alloyed; waste and scrap; powders, alloyed	10.2%	6.5%	Free	Free	B

CHAPTER 81 (cont'd)

Tariff Item	Description of Goods	Canada MFN	Canada GPT	United States MFN	United States GPT	Phase-Out in FTA
81.08	Titanium, including waste and scrap					
8108.10	-Unwrought titanium; waste and scrap; powders					
8108.10.10	---Unwrought titanum, not alloyed; powders, not alloyed	4%	Free	Free	Free	B
8108.10.20	---Unwrought titanium, alloyed; waste and scrap; powders, alloyed	10.2%	6.5%	(1)	(1)	B
81.09	Zirconium, including waste and scrap					
8109.10	-Unwrought zirconium; waste and scrap; powders					
8109.10.10	---Unwrought zirconium, not alloyed; powders, not alloyed	4%	Free	(1)	(1)	B
8109.10.20	---Unwrought zirconium, alloyed; waste and scrap; powders, alloyed	10.2%	6.5%	(1)	(1)	B
8110.00	Antimony, including waste and scrap					
8110.00.10	---Unwrought antimony, not alloyed; powders, not alloyed	4%	Free	Free	Free	B
8110.00.20	---Unwrought antimony, alloyed; waste and scrap; powders, alloyed	10.2%	6.5%	Free	Free	B
8111.00	Manganese, including waste and scrap					
8111.00.10	---Unwrought manganese, not alloyed; powders, not alloyed	Free	Free	(1)	(1)	C,D
8111.00.20	---Unwrought manganese, alloyed; waste and scrap; powders, alloyed	10.2%	6.5%	(1)	(1)	C
81.12	Beryllium, chromium, germanium, vanadium, gallium, hafnium, indium, niobium (columbium), rhenium and thallium, including waste and scrap					
	-Beryllium					
8112.11	--Unwrought; waste and scrap; powders					
8112.11.10	---Unwrought beryllium, not alloyed; powders, not alloyed	4%	Free	(1)	(1)	B
8112.11.20	---Unwrought beryllium, alloyed; waste and scrap; powders, alloyed	10.2%	6.5%	(1)	(1)	B

8112.20	-Chromium					
8112.20.10	---Unwrought chromium, not alloyed; powders, not alloyed	4%	Free	(1)	(1)	B
8112.20.20	---Unwrought chromium, alloyed; waste and scrap; powders, alloyed	10.2%	6.5%	(1)	(1)	B
8112.30	-Germanium					
8112.30.10	---Unwrought germanium, not alloyed; powders, not alloyed	4%	Free	(1)	(1)	B
8112.30.20	---Unwrought germanium, alloyed; waste and scrap; powders, alloyed	10.2%	6.5%	(1)	(1)	B
8112.40	-Vanadium					
8112.40.10	---Unwrought vanadium, not alloyed; powders, not alloyed	4%	Free	(1)	(1)	B
8112.40.20	---Unwrought vanadium, alloyed; waste and scrap; powders, alloyed	10.2%	6.5%	(1)	(1)	B
	-Other					
8112.91	--Unwrought; waste and scrap; powders					
8112.91.10	---Unwrought metal, not alloyed; powders, not alloyed	4%	Free	3.7%	Free	B
8112.91.20	---Unwrought metal, alloyed; waste and scrap; powders, alloyed	10.2%	6.5%	Free	Free	B